Maintenance manual

9009
AM/FM Modulation Meter

Modulation Meter 9009

HANDBOOK AMENDMENTS

Amendments to this handbook (if any), which are on coloured paper for ease of identification, will be found at the rear of the book. The action called for by the amendments should be carried out by hand as soon as possible.

'POZIDRIV' SCREWDRIVERS

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SECTION 1

TECHNICAL SPECIFICATION

TECHNICAL SPECIFICATION

INPUT CHARACTERISTICS

Carrier frequency range (Automatic operation)	30 MHz to 1500 MHz. Automatic measurements can also be made in the bands 10 MHz to 13 MHz and 20 MHz to 26.5 MHz.
Carrier frequency range (Manual tuning)	8 MHz to 1500 MHz using external local oscillator with a range of 13 to 28 MHz. Input required 200 mV to 1V r.m.s. into 50Ω. -1dBm +15dBm.
Input level	Low input: 10 to 100 mV r.m.s. to 500 MHz. 20 to 150 mV r.m.s. from 500 MHz to 1 GHz 50 to 150 mV r.m.s. from 1 GHz to 1.5 GHz. (temp range above 1 GHz +10°C to +30°C) High input: 100 mV to 1V r.m.s. to 500 MHz. 150 mV to 1V r.m.s. from 500 MHz to 1 GHz.
Level setting	Fully automatic.
Input impedance	50Ω nominal.

FM MEASUREMENT

Deviation ranges		1.5, 3, 5, 10, 15, 30, 50 and 100 kHz peak deviation f.s.d. Measurements of positive and negative deviations can be made.
Modulation frequency range		50 Hz to 30 kHz
Accuracy		±2% of f.s.d, ± 1% of reading at 1kHz.
Frequency Response:	(1)	±0.2dB with respect to 1kHz from 300Hz to 3kHz. ±0.5dB with respect to 1kHz from 50Hz to 10 kHz. -3dB ± 0.75dB with respect to 1kHz at 30kHz.

FM MEASUREMENT.

Residual f.m. noise	-46dB with respect to 10kHz peak deviation measured on the AF output with the 3kHz filter IN at carrier frequencies up to 250MHz, then increasing at 6dB/octave above this frequency.
AM rejection	Additional deviation error is less than 250 Hz with an a.m. depth of up to 80% and a modulating frequency in the range 300 Hz to 3 kHz.

AM MEASUREMENT

Modulation depth ranges	5, 10, 15, 30, 50 and 100% f.s.d. modulation depth. Measurements of either peak or trough relative to mean carrier can be made.
Modulation frequency range	50 Hz to 30 kHz.
Accuracy	±2% of f.s.d. ± 1% of reading at 1 kHz.
Frequency Response	±0.2dB with respect to 1kHz from 300 Hz to 3kHz ±0.5dB with respect to 1kHz from 50Hz to 10kHz. -3dB ±0.75dB with respect to 1kHz at 30kHz.
Residual a.m.	Less than 1% modulation.
f.m. rejection	Additional a.m. error is less than 2% with peak deviations of up to 100 kHz.

IF OUTPUT

Frequency	500kHz, nominal.
Level	100 mV r.m.s. e.m.f., nominal.
Output impedance	600Ω nominal.

DC OUTPUT

Rear Panel Socket	Proportional to meter reading. 1V e.m.f. (nominal) at f.s.d. (10 scale) Output impedance 10 kΩ.

AF OUTPUT

Bandwidth	Normal: 50 Hz to 10 kHz ± 0.5 dB. At 30 kHz*, -3dB ± 0.75dB With Filter: 300 Hz to 3 kHz at 2 dB points. *Refer to curves on pages Tech. Spec. (4) and (5) for typical frequency response up to 30 kHz.
Level	1V r.m.s., e.m.f., nominal, when meter is at f.s.d.
Output impedance	600Ω nominal.
Distortion	Less than 0.5% for f.m. deviations up to 100 kHz. Less than 1% for a.m. depths up to 80% (typically 0.5%) at input levels less than 50 mV (500 mV high level input).

POWER REQUIREMENTS

Voltage ranges:	104V to 126V; 207V to 253V
Frequency	45 to 440 Hz
Power Consumption	Approximately 15 VA.

ENVIRONMENTAL CONDITIONS:

Operating temperature	0 to +55°C (0°C to +40°C with battery pack).
Storage temperature	-40°C to +70°C, (-40°C to +50°C with battery pack

DIMENSIONS

Height 83mm (Case only): 110mm (Overall)
Width 241mm (Case only): 284 mm (Overall)
Depth 268mm.
Weight 2.5 kg approximately.
(4 kg approximately with battery pack).

OPTIONS

Battery pack kit (Part No. 11-1253)	10 rechargeable Nicket Cadmium cells give approximately 6 hours continuous operation. The charger in the 9009 enables cells to be trickle charged during normal mains operation. A discharged battery can be fully charged in approximately 14 hours by selecting CHARGE.
Carrying Case: Part No. 15-0450	

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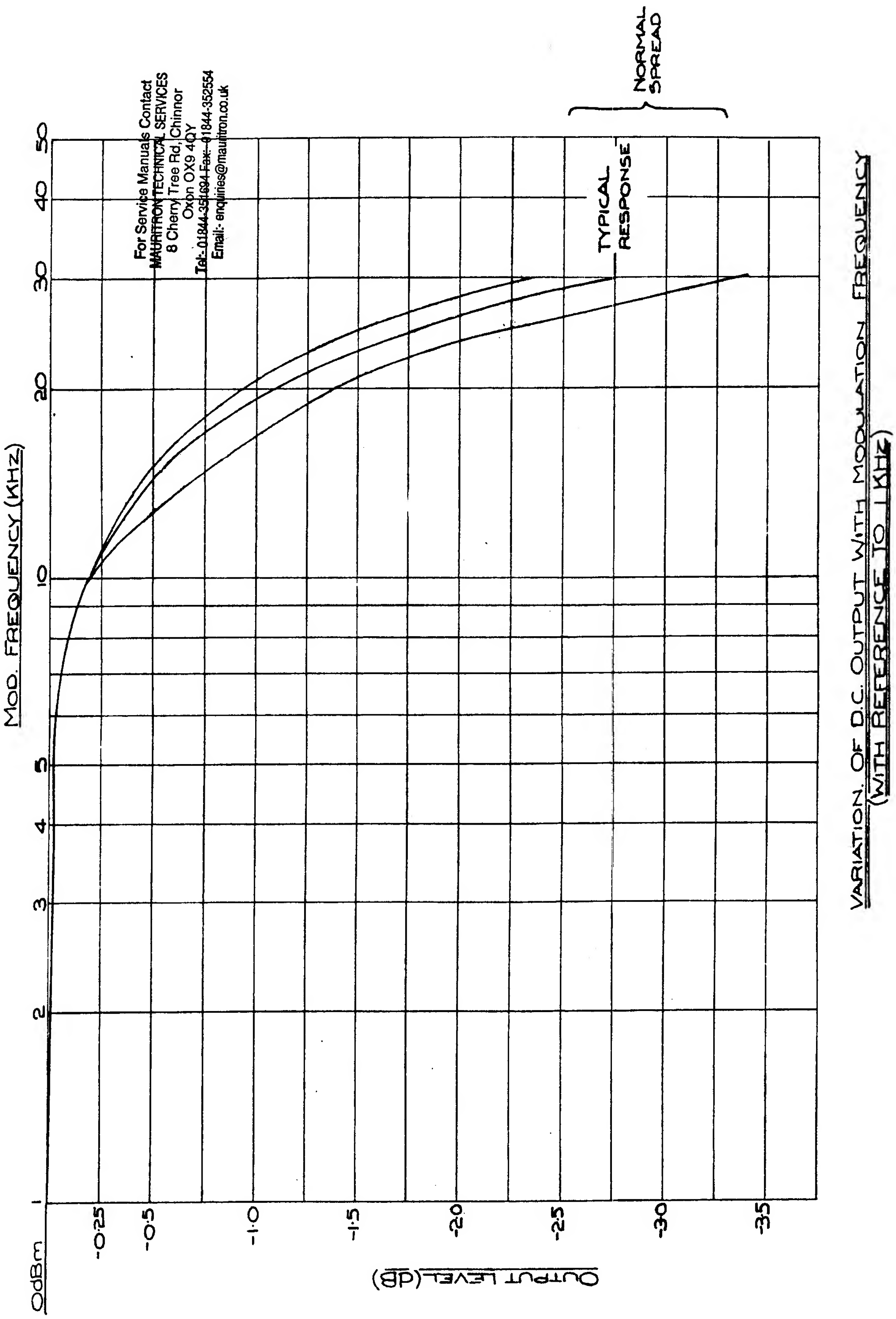

MOD. FREQUENCY (KHz)
1
2
3
4
5
10
20
30
40
50
OUTPUT LEVEL (dB)
0dBm
-0·25
-0·5
-1·0
-1·5
-2·0
-2·5
-3·0
-3·5
TYPICAL RESPONSE
NORMAL SPREAD
VARIATION OF D.C. OUTPUT WITH MODULATION FREQUENCY
(WITH REFERENCE TO 1 KHz)

Fig. A1

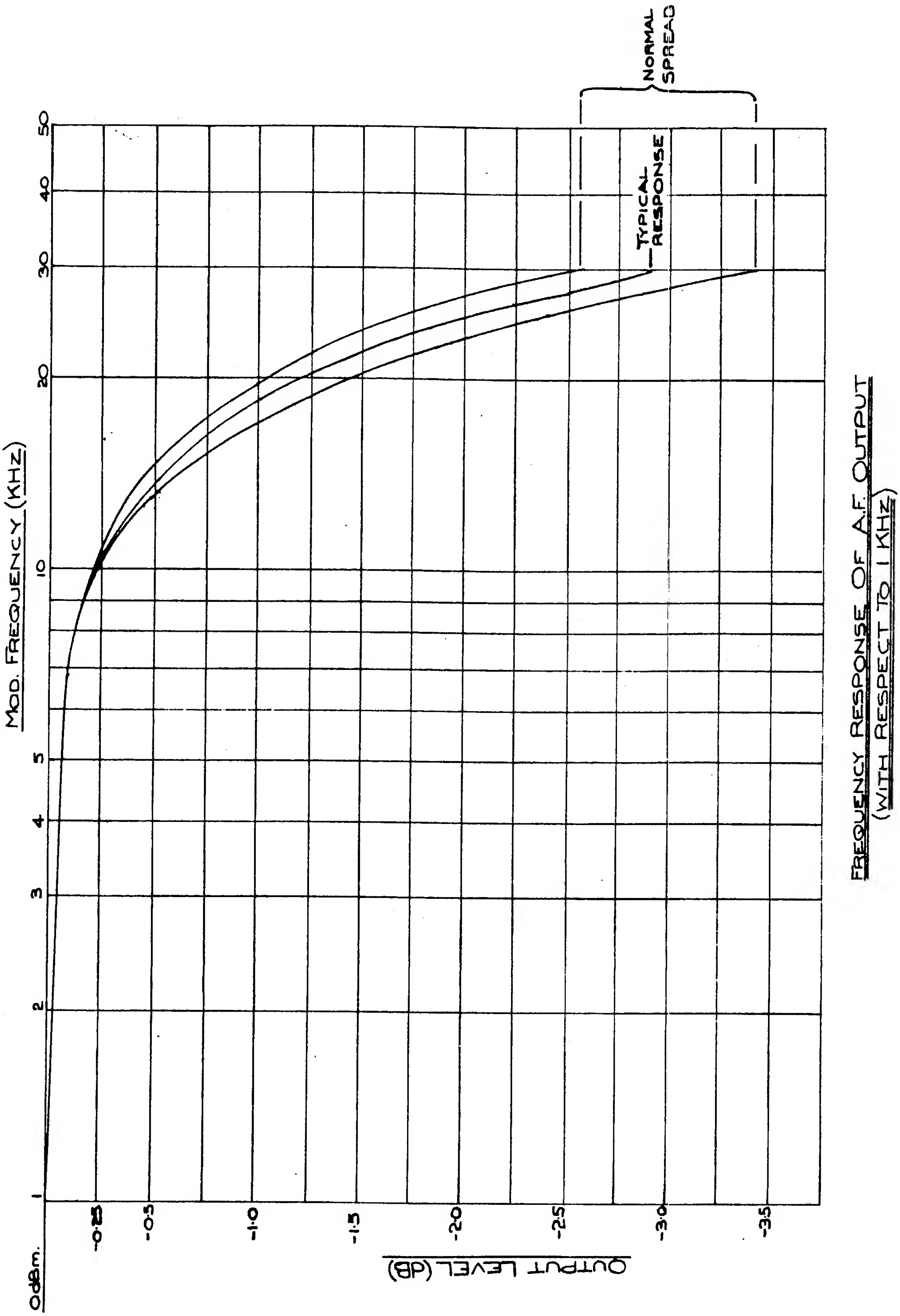

FREQUENCY RESPONSE OF A.F. OUTPUT
(WITH RESPECT TO 1 KHz)
MOD. FREQUENCY (KHz)
1
2
3
4
5
10
20
30
40
50
OUTPUT LEVEL (dB)
0dBm.
-0.25
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
NORMAL SPREAD
TYPICAL RESPONSE

Fig. A2

SECTION 2

DESCRIPTION

OPERATION & MAINTENANCE

CHAPTER 1

INTRODUCTION AND OPERATING

INTRODUCTION

General

1.1 The Racal Modulation Meter 9009 provides a simple and unambiguous method of measuring the modulation depth of a.m. signals and the peak deviation of f.m. signals. A feature of the instrument is the entirely automatic tuning and level setting, with manual tuning also being available.

Operating Ranges

1.2 The automatic tuning is operative within the bands 10 to 13.0MHz and 20.0 to 26.5MHz, and continuously from 30MHz to 1.5GHz. By using a suitable (13-28MHz) external oscillator a manual tuning range of 8MHz to 1.5GHz is obtainable.

Facilities and Display

1.3 Measurements of peak deviation in eight ranges and modulation depth in six ranges are clearly displayed on a meter. A divide-by-two Meter Range switch enables readings always to be taken in the upper half of the meter scale where measurement is more accurate. A switched A.F. Filter is provided for use in conditions of high signal noise.

Input and Outputs

1.4 On the front panel there are two sockets for signal input; one (commonly referred to as the Low Level input) accepts signal levels in the range 10mV to 100mV up to 500MHz and 20mV to 150mV above 500MHz. The other (High Level) input has an operating range of 100mV to 1V up to 500MHz and 150mV to 1V above 500MHz. The third front panel socket is for the external oscillator input used in manual operation. On the rear panel the 500kHz i.f., the demodulated a.f. and a d.c. (analogue) output equivalent to the meter reading, are available at BNC sockets.

Operating Manual

1.5 For a description of operational controls, reference should be made to the Operator's Manual supplied with each instrument. Operating instructions are on page 1-3.

Battery Operation

1.6 The instrument is designed for operation either from normal a.c. mains supplies, or from an optional battery pack containing re-chargeable nickel cadmium cells, which

can be fitted internally. The batteries allow approximately 6 hours continuous operation from the full charged condition and come into operation automatically whenever the a.c. supply is disconnected (See Note below).

IMPORTANT NOTE:

When the instrument is out of use (a.c. supply disconnected) check that the POWER switch is set to CHARGE, otherwise battery power will automatically come into operation with consequent discharge of the batteries.

1.7 With the battery pack fitted and the instrument connected to the a.c. supply the internal power circuit will operate as a battery charger whenever the POWER switch is set to the CHARGE position. Complete charging requires 14 hours although inadvertent over-charging up to 48 hours maximum will not cause any damage to the batteries. Long-term battery life may, however, be adversely affected if the batteries are allowed to charge for periods longer than 48 hours. When the instrument is operating from the a.c. mains supply the batteries receive a trickle charge which can continue indefinitely without detriment to the batteries.

Power Supply

1.8 The instrument operates from a nominal 115V to 230V a.c. supply, 45 to 440Hz. Soldered links within the unit must be correctly set according to the supply voltage to be used. (Refer to Chapter 4).

CALIBRATION

1.9 Calibration of the measurement circuits requires test equipment of high quality to match the specification of 9009, particularly with respect to low noise and modulation accuracy. The customer is recommended to take advantage of the calibration service offered by Racal Instruments Ltd and authorized Racal agents.

OPERATING INSTRUCTIONS

NOTE 1 Before using the instrument for the first time, or at a new location, the power supply should be checked as described on page 4-3.

NOTE 2 Reference may be made to the frequency response curves on pages Tech. Spec. (4) and Tech. Spec. (5) for operation with modulation frequencies higher than 10 kHz.

AUTOMATIC OPERATION

1.11 (1) Set the controls as follows:-

(i) POWER switch to ON.

(ii) AUTO/OSC switch to AUTO. Switch off external oscillator (if connected).

(iii) FUNCTION switch to A.M. or F.M., according to the signal to be checked.

(iv) A.F. FILTER to OUT.

(v) PEAK/TROUGH switch as required.

(vi) The two-position METER SCALE switch to the 3/100 position.

(vii) The METER RANGE switch to the 100/50 position.

(2) Connect the signal to be checked to the appropriate INPUT socket. If the amplitude is not known use the 1V r.m.s. socket initially.

(3) The IN LOCK lamp should show a steady illumination, if it continues to flash the cause is likely to be one of the following:-

(a) Signal level too high.

(b) Signal level too low.

(c) Signal frequency outside the automatic operating range.

To deal with (a) or (b) check that the appropriate input socket is in use.

(4) A meter reading may be taken as soon as the IN LOCK lamp gives a steady illumination. Set the METER RANGE and/or METER SCALE switches to give the most convenient indication on the meter scale.. Under noisy signal conditions the A.F. FILTER may be switched in IN.

(5) Read off the measurement from the appropriate scale on the meter, according to the settings of the METER RANGE and SCALE switches.

MANUAL TUNING OPERATION

1.12 (1) Connect a tunable oscillator with a range of 13-28MHz to the EXT. OSC. socket. (The required input level is 200mV-1V r.m.s. into 50 ohm).

NOTE: It should be appreciated that the oscillator frequency is divided by two, therefore the external oscillator frequency must be not less than 13MHz. This will ensure coverage of input signals down to 8MHz.

(2) Set the AUTO switch to EXT. OSC.

(3) Switch POWER to ON.

(4) Set the FUNCTION switch to TUNE and the A.F. FILTER to OUT.

(5) Connect the signal source to the appropriate INPUT socket.

(6) The METER switches are not relevant at this point and may be in any position; the meter will be displaying a steady reading at about half-scale.

(7) Tuning

NOTE: To avoid 'image frequency' tuning the following procedure should be followed exactly. The correct i.f. can be obtained at various settings of the external oscillator tuning, thus several meter responses may be found which will be of equal suitability provided the tuning procedure is followed precisely.

(i) Set the external oscillator initially to the higher frequency end of its range.

(ii) Tune the oscillator slowly downwards in frequency until the meter reading goes hard over to f.s.d.

(iii) At this point reverse the tuning direction and increase the oscillator frequency until the meter reading falls to the 'tune' diamond on the meter scale. This is the required tuning point.

(8) Set the FUNCTION switch to A.M. or F.M., as required.

(9) Set the METER RANGE and METER SCALE switches, as required, to give a suitable deflection for accurate measurement.

(10) Read off from the appropriate scale of the meter, according to the settings of the METER RANGE and SCALE switches.

CHAPTER 2

PRINCIPLES OF OPERATION

NOTE: In reading this chapter reference should be made to the explanatory block diagram Fig. 2.1 located at the end of this chapter. The overall block diagram Fig. 8 (at the back of the book) gives greater detail, relating circuit functions to the separate p.c.b. Assemblies as well as showing interconnections.

SUMMARY

2.1 The Modulation Meter 9009 dispenses with the tedious tuning and level setting procedures of conventional modulation meters by exploiting the principle of the Sampling Mixer combined with a frequency - locked loop controlling a local oscillator. If required an external manually tuned oscillator may be used, which extends the operating range of the instrument.

2.2 The input signal, and the signal derived from the local oscillator are applied to separate inputs of the Sampling Mixer. By tuning the oscillator a point will be found at which a 500kHz "difference frequency" is obtained at the output from the Sampling Mixer. This is the required tuning point, which is achieved automatically by the oscillator control loop when on AUTO operation or by manual tuning when using an external oscillator.

2.3 The output signal from the Sampling Mixer (referred to as the i.f.) is offered two distinct paths:-

(a) Via an automatic level control (a.l.c.) stage to the a.m. and f.m. detectors of the measurement circuit.

and (b) Via a low-pass filter to the oscillator control loop.

2.4 The a.l.c. stage in the measurement path ensures that a constant mean i.f. signal level is applied to the a.m. detector. By virtue of this constant input level a reading of percentage modulation depth can be obtained by measuring the absolute value of the detected audio signal and applying this measurement to the meter. A 'peak and trough' switch permits measurement of both positive and negative-peaks of the modulating waveform.

2.5 On F.M. measurements the signal (i.f.) is applied to a 'pulse' discriminator which has an output level proportional to frequency. The amplitude of this output waveform has a mean level which corresponds to the i.f. Variations from this level represent positive and negative peak deviations. These variations are 'peak and trough' detected and displayed as a meter reading.

FUNCTIONAL DETAILS

2.6 The principles of the instrument will be now discussed in slightly greater detail.

Signal Input

2.7 Alternative front panel input sockets are provided. The "high level" input feeds into a 20dB attenuator whereas the "low level" input signal is applied direct to the input of the Sampling Mixer. The Input Attenuator and the Sampling Mixer are mounted on separate p.c.b. Assemblies. The remainder of the signal processing and measurement circuitry is mounted on a large p.c.b. referred to as the Motherboard.

Sampling Mixer

2.8 Referring to Fig. 2.1, the divided output from the voltage controlled local oscillator drives a pulse generator, thus producing a train of narrow pulses (fs) which are applied to an input of the Sampling Mixer. The external signal (fi) which is applied to the other input of the mixer, is sampled by this pulse train. If a harmonic of the sampling frequency 'fs' is identical in frequency to the external signal, the output frequency from the sampling mixer (the i.f.) will be zero. When the two frequencies are not identical a "difference" frequency output will be obtained.

2.9 The frequency relationship can be expressed by the formula:-

$$\text{i.f.} = (N.fs - fi)$$

where N.fs is that harmonic of fs closest to the external signal fi.

2.10 In AUTO operation it is the function of the control loop to sweep the oscillator (and hence the sampling frequency) until a 500 kHz difference frequency (the i.f.) is obtained at the sampler output. The oscillator frequency is then held at this point.

'In Lock Indication'

2.11 The IN LOCK lamp is driven by a multivibrator which has three control lines. The multivibrator will run and cause the 'IN LOCK' lamp to flash until the required conditions on the three control lines are satisfied. These lines are identified as A, B and C on Fig. 2.1. Measurements are not valid until the flashing indication is replaced by a steady illumination.

2.12 The conditions which can cause the IN LOCK lamp to flash are:-

Condition 1 ..... I.F. level (i.e. input level) too high (Control 'A')
Condition 2 ..... I.F. level (i.e. input level) too low (Control 'B')
Condition 3 ..... Input frequency out of range. (Control 'C')

The Oscillator Control Loop (Auto Operation)

2.13 Let it be assumed that the local oscillator, an AUTO operation, is searching for

the required tuning point. The output from the Sampling Mixer (which is not yet at the required 500kHz) is applied via a low-pass filter and limiter to the discriminator stage.

2.14 The output from the discriminator is a d.c. voltage which is proportional to the frequency of the i.f. This d.c. voltage is applied to one of the inputs of an integrator, the other input being a fixed d.c. reference voltage. This reference voltage has a value such that when the frequency of the i.f. reaches 500kHz, the discriminator output level will equal the reference voltage.

2.15 The reference and discriminator voltages are summed in the integrator, the resulting output being applied as a tuning voltage to the oscillator, as follows.

2.16 For example, if the i.f. exceeds 500kHz the discriminator output level will be greater than the reference voltage and the integrator output will act to reduce the oscillator frequency until the exact 500kHz i.f. is achieved. At this point discriminator and reference voltages will be equal. The necessary oscillator search is initiated by a Hunt Generator circuit.

2.17 The function of the Hunt Generator is to produce a sweep voltage which will bring the oscillator frequency into the capture range of the frequency-locked loop. The discriminator voltage and the reference voltage (see para. 2.14) are compared in a Voltage Comparator circuit, the output of which controls the Hunt Generator. If a 'difference' exists between the two comparison voltages the Hunt Generator will remain in action until the two voltages almost coincide (i.f. approximately 500kHz). At this point the Hunt Generator turns off.

2.18 The output of the Voltage Comparator, which drives the Hunt Generator, is also applied as an 'out of range' signal to the In-Lock multivibrator circuit. (Control 'C' in Fig. 2.1). Thus, if the frequency locked loop is unable to lock because the input frequency is out of range, the Hunt Generator will remain in action and the In Lock multivibrator will maintain a flashing signal on the indicator.

In-Lock Detection System

2.19 The principles of the system are summarized in paras. 2.10 and 2.11. The three indication signals are applied to a triple And gate which controls a multivibrator. The out of range signal has been discussed in the previous paragraph. If, the input signal is too low (Control 'B') this is detected by a low level on the i.f. line to the discriminator. Too high an input signal, on the other hand, is notified by a d.c. voltage developed in the a.l.c. stage in the measurement path (Control 'A'). Until all three control conditions are satisfied the multivibrator will continue to run, thus maintaining a flashing signal at the In Lock indicator. Note that the system is "fail safe" in that the lamp is never turned off except when the instrument is inoperative. A failed lamp cannot cause misreading.

The Oscillator Output

2.20 The oscillator output is fed to the Sampling Mixer Assembly, where, after binary division it drives a pulse generator which in turn drives the sampling mixer.

Measurement Circuits

2.21 The measurement signal path is shown in heavy line in Fig. 2.1. From the input to the main board the i.f. is fed via a low-pass filter to the Auto Level Control (A.L.C.) stage.

2.22 For accurate a.m. measurement the mean carrier level of the i.f. must be constant; this is ensured by feedback from the a.m. detector to the a.l.c. stage.

2.23 The level-controlled i.f. signal is supplied simultaneously to the a.m. detector and f.m. discriminator, the required facility being selected by the Function (AM/TUNE/FM) switch. The TUNE position has no significance at this point.

2.24 From the Function switch the audio signal is fed via an amplifier and filter to the PEAK/TROUGH switch S5. This switch selects the signal either direct or via an inverting amplifier.

2.25 From the Peak/Trough switch the audio signal is offered alternative paths, either direct or via the a.f. filter. Filter selection is made by the A.F. FILTER (IN/OUT) switch on the front panel.

2.26 The four-position METER RANGE switch together with its associated toggle switch (for convenience referred to as the Meter Scale switch) effectively provides eight attenuation settings to accommodate a wide range of modulation depths, thus enabling most readings to be taken in the upper half of the meter scale where measurement is more accurate.

2.27 From the 2nd A.F. Amplifier the audio signal is fed to a peak detector and also to an A.F. Output socket on the rear panel. The peak detector provides a positive d.c. output to the meter, this d.c. signal also being available at a socket on the rear panel. The Peak Detector operates on positive half-cycles of the audio waveform. The Peak/Trough switch referred to in para. 2.24 enables both positive and negative peaks of the demodulated waveform to be measured.

Manual Tuning

2.28 For manual operation an external tunable oscillator may be connected to the EXT OSC socket. The oscillator requirements are a frequency range of 13 to 28MHz and output level between 200mV and 1V r.m.s. into 50 ohms. With the AUTO switch set to EXT OSC the internal local oscillator is inhibited and the external oscillator signal is fed via a buffer on the main board to the divider and pulse generator on the Sampling Mixer Assembly. To avoid the possibility of 'image frequency' tuning, the manual tuning instructions in the Operator's Manual must be followed precisely.

2.29 Although the internal oscillator frequency-locked loop has no control function when on EXT. OSC., the integrator output voltage is fed to the TUNE position of the

Function switch to provide a meter reading for manual tuning; the integrator for this purpose being converted to a fixed gain amplifier.

Battery Check

2.30 The state of charge of the battery pack (if fitted) can be checked by depressing switch S3 to BATTERY CHECK. This disconnects the meter from the modulation measurement circuits, and connects it to the battery check circuit. A reading within the green portion of the meter scale indicates a satisfactory state of charge. It should be noted that this check is valid only when the battery is on load. For this reason a reading can be obtained only when the a.c. supply is disconnected and the instrument is switched on.

Battery Charging

2.31 A mains-powered battery charging circuit is built into the instrument, although the battery pack is available only as an optional item. The batteries will receive a trickle-charge whenever the instrument is operating from an a.c. mains supply. The maximum charge rate is obtained by setting the POWER switch to CHARGE. The recommended charging time is 14 hours during which the instrument is inoperative. Advice on correct battery operation is given in Chapter. 1 and it is essential that this be noted.

A.C. Power Supply

2.32 The a.c. supply is connected via a 3-pin fixed plug on the rear panel feeding through a single line fuse and mains filter Assembly to the power transformer. Mains voltage selection is made by means of soldered links on a terminal panel inside the instrument. Instructions are given in Chapter 4. (Also in Chapter 2 of the Operator's Manual).

CHAPTER 3

TECHNICAL DESCRIPTION

INTRODUCTION

3.1 This chapter describes the significant features of the circuit design. The reader should have a clear understanding of the functional principles described in Chapter 2 and a basic knowledge of solid-state circuit theory and logic. The circuit descriptions will be dealt with under three main headings:-

(a) Input circuits, describing the input attenuator and Sampling Mixer Assembly.

(b) The main p.c.b.; in which the description will deal separately with

(i) The frequency-locked loop and oscillator.

and

(ii) The measurement circuits.

(c) The power supply and battery charging system.

INPUT ATTENUATOR 19-0761

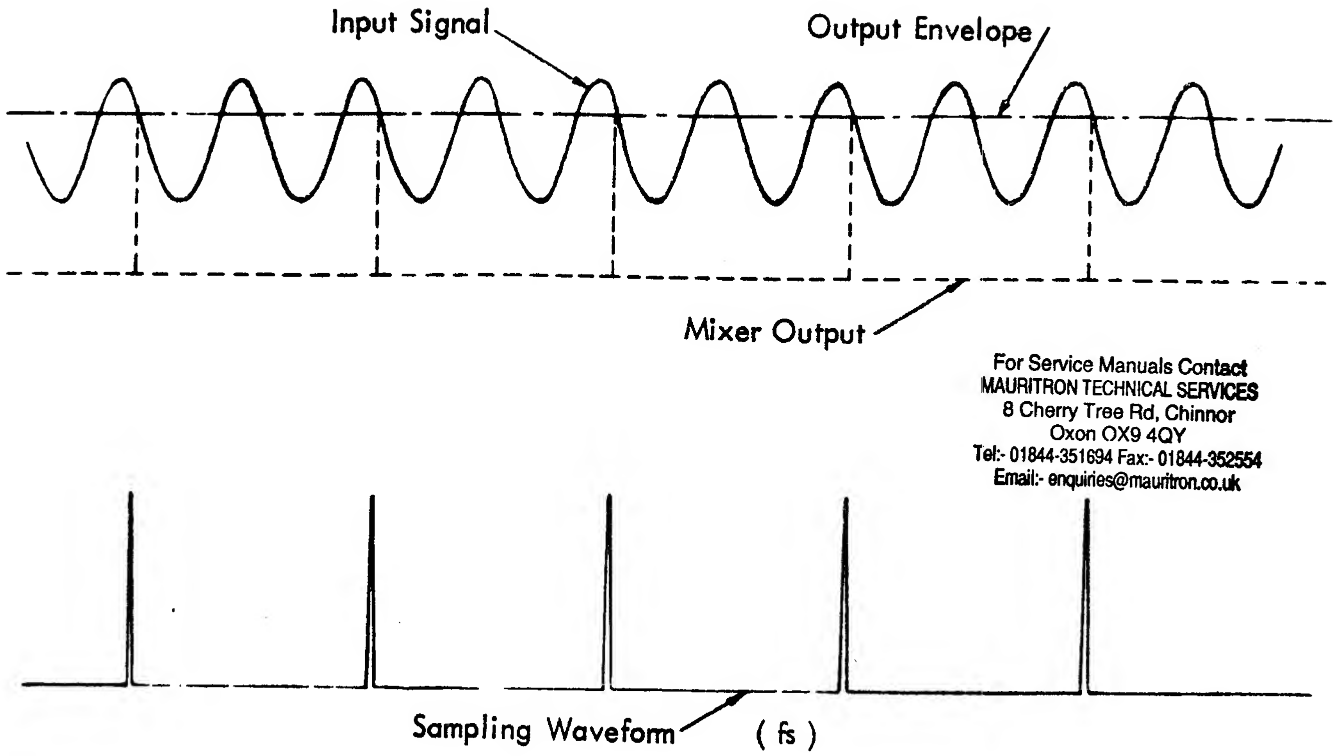
3.2 The input attenuator is mounted on a small board which is positioned close to front panel input sockets. Referring to the circuit diagram Fig. 1, signals at higher levels are fed in on input socket SK2 and conveyed via a length of 50 ohm transmission line to the 56 ohm terminating resistor R1. The attenuator is R2 which feeds into a 51 ohm terminating resistor on the Sampling Mixer Assembly (see Fig. 3). Capacitor C2 provides frequency compensation to equalise the response up to 1GHz. Low-level signals applied via SK1 are fed direct to the Sampling Mixer.

SAMPLING MIXER ASSEMBLY 19-0742

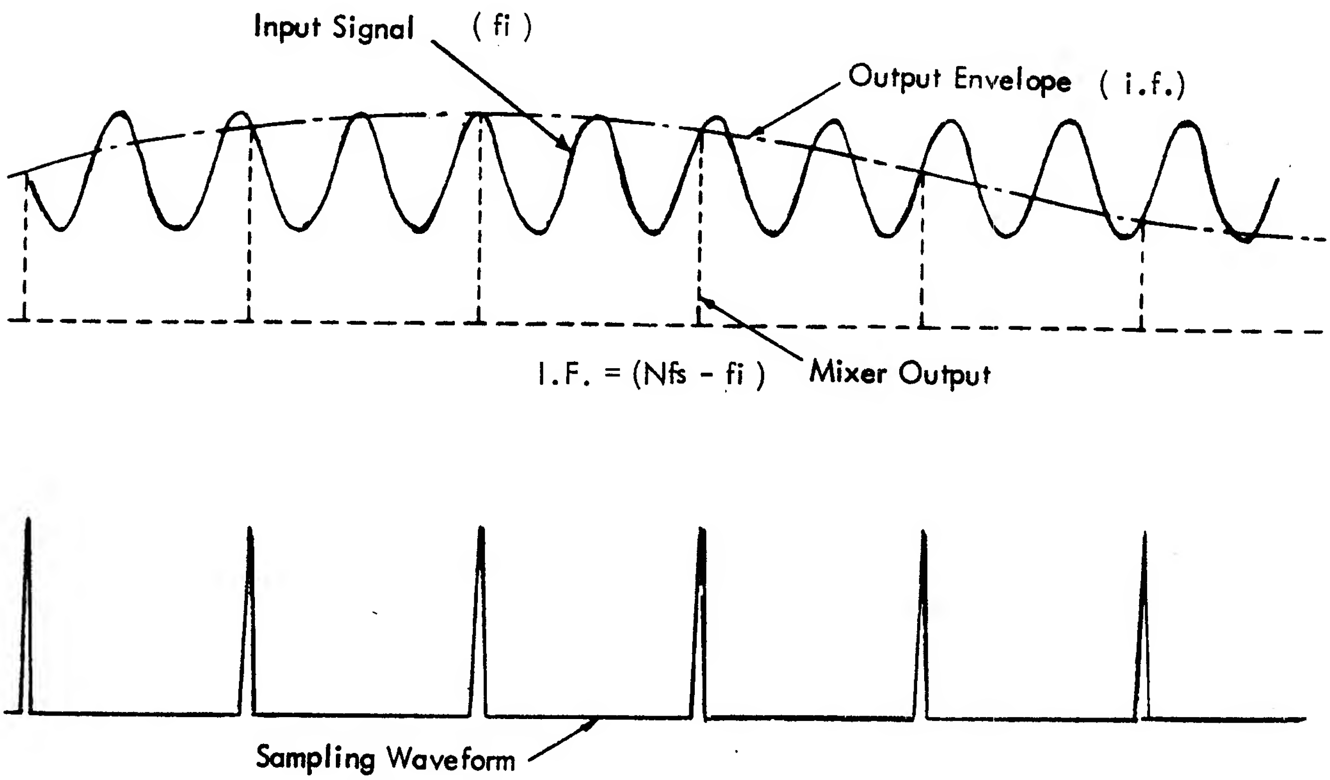
3.3 Referring to the circuit diagram Fig. 3, at the back of the book, this circuit may be considered, functionally, in two parts; the pulse generator section on the right of the diagram and a sampling mixer and i.f. output on the left.

Pulse Generator

3.4 The 20-28MHz signal from the local oscillator(either internal or external) is fed into IC1b which is one half of a high speed Dual-D package operating as a divide-by-two stage.



Sampling Waveforms in "Zero Beat" Condition Fig. 3.1



Sampling Waveforms in "Frequency Difference" Condition Fig. 3.2

3.5 From IC1b the divided oscillator signal is fed via shaper Q3 into a step-recovery diode pulse generator which produces a very fast pulse on the negative edge of Q3 collector output. The output from the pulse generator is fed in anti-phase via a transmission line transformer T1 to capacitors C2 and C3. The +5V supply to the divider and pulse generator section is stabilized by Q4 and D5.

The Sampling Mixer and I.F. Output

3.6 The external signal is fed via C1 to the junction of diodes D1 and D2 in the sampling bridge formed by D1, D2, R2 and R3. The positive and negative-going pulses from the pulse generator, which are fed via C2 and C3, briefly overcome the reverse bias of the sampling diodes, allowing a voltage related to the instantaneous value of the input signal voltage to appear on C2 and C3, this voltage being applied to the resistors R2 and R3 during the inter-pulse period.

3.7 If the sampling and signal frequencies are harmonically related the voltage applied to Q1 gate will be at zero frequency (d.c.), but if a frequency difference exists the output envelope will vary in amplitude at this difference frequency (the i.f.). The output envelopes for "zero beat" and "frequency difference" conditions are shown in Fig. 3.1 and 3.2. For a detailed discussion of sampling mixer principles reference should be made to a standard text book on the subject.

3.8 The output stage Q1/Q2 operates in a boot-strapped source-follower configuration with an overall gain of two. The i.f. output from Q2 collector is fed via pin 3 to the main p.c.b.

FREQUENCY-LOCKED LOOP AND OSCILLATOR CONTROL

Introduction

3.9 The circuitry for the frequency-locked loop and local oscillator is mounted on the main p.c.b. Essential diagrams for reference are the block diagram in Chapter 2 (Fig. 2.1) and the circuit diagram at the back of the book (Fig. 6).

I.F. Input Amplifiers

3.10 The i.f. signal from the Sampling Mixer enters the main p.c.b. at pin 1 and diverges into two paths. The description of the Measurement path commences at para. 3.44. Referring to the circuit, Fig. 6, the i.f. signal to the frequency-locked loop is fed via R201 into a low-pass filter which removes unwanted sampling mixer frequencies before offering the signal to the amplifiers Q204 and Q207.

3.11 Transistors Q204 and Q207 are high-gain shunt feedback amplifiers with constant current supplies via Q203 and Q206 respectively. The diodes D203 and D207 are limiters which prevent saturation of Q204 in the presence of high level input signals.

3.12 The output from Q207 (at test point TP15) diverges into two paths:-

(a) Via C211 into the discriminator circuit for oscillator control purposes.

(b) Via C207 to the Level Detector for "signal level too low" detection.

The low-level detector will be discussed in a later paragraph (para. 3.42).

Discriminator

3.13 From Q207 the i.f. signal is fed via C211 and R219 to the base of the switching amplifier Q209 which gives a square wave output. The collector of Q209 is fed from a stabilized +7V supply to ensure constant output amplitude. The catching diode D208 ensures correct biasing of Q209 in the event of excessive signal amplitude or overmodulation.

3.14 Q209 switches alternately hard on and off in response even to small i.f. inputs. During the conducting period the capacitor C213 charges from the +10V supply via D202. When Q209 switches off, however, its collector voltage rises towards +7V and Q210 becomes forward biased by the voltage stored on C213. This allows the stored charge in C213 to flow into C214 and R223. The current pulses flowing from Q210 are smoothed by C214 and the average current flows through R223, producing a mean d.c. voltage which is proportional to the frequency of the i.f. signal. This mean voltage is applied to the base of Q211.

Integrator

3.15 The d.c. output from the discriminator at Q211 emitter (Test Point TP16) is fed via a potential divider network R229, R232 to the integrator-operational amplifier IC202 via the input resistor R233. The output at IC202/6 is applied via link LK1 to the varactor control of the local oscillator Q230. Link LK1 is provided to permit the frequency control loop to be broken for test purposes.

3.16 A reference voltage supplied via Q226 and preset by R295 is applied via R234 to IC202/3. The control voltage developed at IC202/6 will adjust the local oscillator frequency (and hence the i.f. via the sampling mixer) until the discriminator output (at TP16) equals the reference voltage at TP18. When this occurs the control loop has reached the locked condition.

3.17 Capture Range. The ability of the integrator to tune the oscillator over a certain frequency range and achieve this locked condition is referred to as the capture range of the loop. Outside this capture range a hunt generator comes into action and applies a sweep voltage to pin 2 of IC202 via Q213 or Q214. This is discussed in more detail commencing at paragraph 3.22.

3.18 The diodes D210 and D215 are reverse-biased on AUTO operation; their function is relevant only to manual tuning (see para. 3.43).

Local Oscillator

3.19 The oscillator is a field effect transistor (FET) Q230 with voltage variable capacitance (varactor) diodes D211 and D212 operating in a Colpitts type circuit. The oscillator output is taken via a tap on inductor L203 to the base of output amplifier Q229 which is over-driven by the oscillator signal, thus feeding a square wave output to the Sampling Mixer p.c.b.

3.20 To ensure minimum noise on the local oscillator signal it is important to remove any extraneous noise or hum voltages from the varactor control line. This is accomplished by the time constant R284/C234. However, to ensure rapid lock-up, R284 is by-passed by Q232 during the time that the hunt waveform is operative. The control signal for this is obtained from IC203 pin 11 via Q233.

3.21 For manual tuning operation the AUTO/EXT OSC. switch S7a is set to EXT OSC which disconnects the +10V from R277/C228, thus inhibiting the local oscillator (and also the hunt generator). The output amplifier Q229, however, remains operative to accept the external oscillator signal from front panel socket SK3 via switch contact S7b and C221.

Hunt Generator

3.22 The Hunt Generator comes into operation (in AUTO mode) when the i.f. lies outside the capture range of the control loop as described in para. 3.16. A quite complex circuit is provided to sense the requirement for hunt generator action and to switch it on and off at the appropriate points. The items particular to the hunt generator system are IC201, IC203, Q213, Q214, Q216, Q217, Q219 and Q221 to Q227. A general description of the hunt control process will be given first, with additional circuit description following at para. 3.35.

3.23 The hunt process operates by turning on either Q214 or Q213, which feeds current into or out of pin 2 of the Integrator IC202. When Q214 is conducting the oscillator is made to hunt downwards in frequency, but when Q214 turns off and Q213 turns on, the loop hunts upward. When the loop is locked, however, both transistors are turned off.

3.24 If the frequency of the i.f. is low (below 500kHz) hunt generator action is not required because the frequency will be within the capture range of the loop. If, on the other hand, the i.f. is high, the hunt generator will be triggered into action when the frequency reaches about 700kHz.

3.25 The need for hunt generator action is determined by the d.c. level at the emitter of Q211 (discriminator output). This voltage is applied via R230/R224 to IC201/3. IC201/2 is supplied with a reference voltage from the same source which supplies the integrator IC202.

3.26 IC201 behaves as a Schmitt Trigger, the output voltage at pin 6 switching between high and low according to the voltage at pin 3 relative to the reference on pin 2.

3.27 For example, if the voltage at Q211 emitter goes high (indicating a high i.f.) it will cause IC201/6 to go high, which via Q212 will apply a '1' to IC203/1. If, at the same time, the latch gate IC203b/IC203c signals a '1' to IC203/2, then a '1' will appear at IC203/11 thus turning on Q213 and initiating an upward hunt at the oscillator.

3.28 The oscillator will hunt up towards the next 'lock' frequency. As it approaches this frequency the voltage at Q211 emitter falls and when it reaches about 2V (i.f. approximately 200kHz) the Schmitt circuit IC201 will switch back again, causing IC201/6 to go low and thus applying a '0' to IC203/1 via Q212.

3.29 This causes IC203/3 to be a '1' and leaves control of the gate IC203d to the signal on IC203/13. In normal operation IC203/13 will be a '1' and therefore the 'hunt up' transistor Q213 will be turned off by IC203/11 going to '0'. The i.f. having been brought within the capture range, the loop will now self-lock, the final tuning being carried out as described in para. 3.16.

3.30 The Schmitt Trigger IC201 will not change state again unless the discriminator output once again rises to about 7V (i.f. 700kHz) at which point IC201 will switch over, thereby carrying on the hunt until the loop tuning is once more within the capture range of the next higher lock frequency.

3.31 Precautions are taken to prevent the oscillator operating at the extreme ends of the tuning range. It has been explained that the oscillator search is always upwards towards the next locking frequency and this is true unless the top end of the oscillator tuning range is reached.

3.32 If this occurs the latch gate IC203b/IC203c will trip, giving a '0' on IC203/8 (which via IC203a and IC203d will switch off Q213). At the same time the '1' which is produced on IC203/6 will turn on Q214 via Q216, thereby applying a 'hunt down' signal to pin 2 of Integrator IC202. This hunt down will continue until the latch gate IC203b/IC203c is tripped to the opposite state.

3.33 The precautionary control described in the previous paragraph is carried out by a circuit involving transistors Q216, Q219 and Q221 to Q228. Of these, Q225, Q227 and Q228 are concerned with the provision of a fixed reference voltage; Q216, Q221 and Q222 are concerned with the 'hunt down' command whilst Q219, Q223 and Q224 are concerned with the 'hunt upwards' command.

3.34 These operations are controlled by referring to the level of the oscillator tuning voltage, a reduced version of which is taken from the junction of R255/R256/R287 to the emitters of Q224 and Q222. Fixed reference voltages derived from Q228 via Q225/Q227, are applied to the bases of Q224 and Q222. Thus the oscillator tuning voltage is compared with a reference voltage to determine whether hunt action is required. The action is as follows:

3.35 If the voltage on the oscillator tuning line rises above approximately +7V it will cause Q222 emitter to rise above the reference level (approx. 6.3V) at its base and Q222 will conduct. The collector current of Q222 will turn on Q221, which pulls IC203/5

down to '0' level. This forces IC203/6 to a '1' condition thus turning on Q216 and also Q214. The latch gate IC203b/IC203c is held in this condition by the feedback to IC203/4.

3.36 The turning on of Q214 applies a hunt down signal at IC202/2. At the same time the '0' on IC203/8, applied via IC203a and IC203d, holds off Q213.

3.37 Once IC203b/IC203c has changed state it will remain latched to the 'hunt down' condition until switched back by a command derived from the 'low' threshold of the oscillator tuning voltage. This command is routed via Q224, Q223 and Q219 in response to the voltage at the junction R255/R256/R287 falling below the reference level of Q224 base.

3.38 The base of Q224 is supplied with a positive reference voltage (approx. 3V) derived from the level at Q227 emitter. When Q224 emitter falls to about 2.3V, Q224 will turn on, causing Q223 and hence Q219 to turn on. This applies a '0' to IC203/10, thereby tripping the latch bistable IC203b/IC203c, causing Q216 and Q214 to turn off thus stopping the 'hunt down' action.

3.39 The '0' at Q219 collector is applied to IC203/13, and immediately sends a '1' to turn on Q213, thus restoring the 'hunt upwards' command. This command will continue until Q219 is once more brought out of saturation by Q224 being turned off by a rising voltage on the oscillator tuning line; the control of Q213 will then revert to the Schmitt Trigger IC201 as described in para. 3.25. The feedback via D205/R260 delays the turning off of Q224 to avoid 'chattering'.

"In-Lock" Indication

3.40 The front panel lamp flashes in the 'out of lock' condition due to the output of IC204, which acts as a multivibrator as a result of the feedback into pins 2 and 3 of the IC, the switching time constant being determined by the values of R257 and C220. Switching will be continuous until pin 3 of IC204 is grounded by the turning on the AND gate transistor Q220, which can occur only when all functional conditions are satisfied (see Chapter 2 para. 2.11).

3.41 The control of Q220 is effected by a direct line to Q220 base from the a.l.c. circuit ("signal level too high") (refer to para. 3.55) and by Q218 which has three control lines to its base. The three control lines to Q218 base are:-

(a) Two lines indicating the 'hunt generator' command state (from IC203/6 and IC203/11 respectively).

(b) One line from the "Low Signal Level" detector via D201.

All these lines must be at '0' for the In Lock condition. The low signal level detector is described in the next paragraph.

Low Signal Level Detector

3.42 The amplified i.f. at Q207 collector is applied via C207 to the base of amplifier Q202, which is biased via Q201 so that it is conducting only on positive half cycles. The output, which is smoothed by C209, biases Q205 into the conducting state provided the signal level is adequate. This turns on Q208 and turns off diode D201, leaving the control of Q218 to the other two lines. If the signal is too low, the signal at Q208 collector will be a '1', thus turning on Q218 which holds Q220 in the non-conducting state and ensures that IC204 causes the IN LOCK indicator to flash.

External (Manual) Operation

3.43 Referring to the circuit diagram, Fig. 6, when the AUTO/EXT OSC switch S7 is set to EXT OSC the frequency control loop is affected as follows:-

(a) The local oscillator is rendered inoperative by disconnection of the +10V supply via S7/A from pin 62.

(b) Switch S7A also disconnects the +10V supply from part of the hunt generator (Q217, Q223, Q224), thus inhibiting the hunt generator transistors Q213 and Q214.

(c) Switch S7C in the EXT OSC position connects the output of IC202 via R291 and pin 53 to the summing input at IC202/2, thus converting IC202 from an integrator to a conventional amplifier. Manual tuning calibration is provided by potentiometer R235, through which a predetermined current is fed via R285 and switch S7C into the summing junction IC202/2. For external operation R235 is preset so that when a 500kHz i.f. is tuned in, the meter needle lies on the correct tuning point (the tune 'diamond' on the scale).

(d) Switch S7A in the EXT OSC position connects +10V to the junction of R292/R235. This applies a forward bias to D210/D215 which allows the discriminator output via IC202 to pass to the Function switch for meter indication of the manual tuning (TUNE mode).

(e) Switch S7b connects the external oscillator to the oscillator output amplifier Q229.

THE MEASUREMENT CIRCUITS

Introduction

3.44 Referring to the Theoretical Block Diagram, Fig. 2.1, in Chapter 2, it can be seen that the Measurement path includes the following principal stages, all of which are mounted on the main p.c.b. Circuit details are in Fig. 7 at the back of the book:-

Automatic Level Control (a.l.c.)

A.M. Detector and F.M. Discriminator

A.F. Amplifiers

Range Attenuator

Peak Detector.

I.F. Input

3.45 On AUTO operation, when the oscillator loop is locked, the 500kHz i.f. enters the main p.c.b. on pin 1 and is fed to the a.l.c. stage via a low-pass filter (formed by R1, C1, L1, C2, C56 and R6) which eliminates unwanted frequencies coming from the sampling mixer.

A.L.C. Stage

3.46 Summary. The voltage gain between the input (R6) of the amplifier and the output (Q5 collector) is determined by the current flowing through Q1. This in turn is controlled by the voltage applied to the base of Q1 by the integrated circuit amplifier IC1.

3.47 The amplifier IC1 compares an a.l.c. signal fed back from the a.m. detector Q22 with a d.c. reference voltage determined by zener diode D1. Any error signal so produced is applied by IC1 to the base of transistor Q1, which varies the gain of the Q1/Q4/Q5 configuration such as to maintain a constant i.f. level (at TP4) into the i.f. amplifier Q6/Q7/Q8 and thence to the a.m. detector Q20/Q21/Q22.

3.48 The correct condition is obtained when the half-wave rectified output from the a.m. detector Q22 has a mean level of approximately 0.5V. In this stable operating condition the feedback from the a.m. detector will produce a mean level of 3.9V on IC1 pin 2 (see also para. 3.55). The a.m. component in this feedback is actively filtered by C4 with R54 and R2/R3 to provide a d.c. control voltage on IC1 pin 6.

3.49 To avoid undue lag in the a.l.c. system the diodes D3 and D4 limit the change of voltage on C4 (between the "signal" and "no signal" conditions) to approximately 0.5V.

3.50 The a.l.c. stage provides a convenient source for the "signal level too high" control of the In Lock indicator system, using the current in Q1 as an information reference, as follows.

3.51 The d.c. current in Q1 flows through Q2. This current, and hence the voltage across R8/R9, is proportional to mean signal level. By adjustment of potentiometer R9 it can be arranged that Q3 will conduct when the input signal reaches the prescribed maximum level, thereby applying a signal to the triple AND gate (Q220) of the In Lock circuit (see para. 3.41).

I.F. Amplifier and A.M. Detector

3.52 From Q5 the i.f. signal at constant mean level is fed to the i.f. amplifier Q6/Q7 and Q8, operating in a "virtual earth" configuration. R14 and R16 with C10 and C11 form a band-pass filter centred on 500kHz. A high-pass filter in the feedback network from Q8 is provided by R18, R19 and C14. From Q8 collector the i.f. signal is fed to the a.m. detector via C29 and to the f.m. discriminator via C17. An i.f. output is also provided on the rear panel (SK4).

3.53 A.M. Detector. The a.m. detector is the virtual earth amplifier Q20/Q21/Q22, together with diodes D15 and D17 and resistor R52. The 3.9V reference from the a.l.c. stage is applied to the base of Q21, thus the detected a.m. component will be added to this 3.9V reference.

3.54 The output at the collector of Q22 is fed to diodes D15 and D17. On negative half cycles D17 is reverse biased whereas D15 conducts to the virtual earth line, thus no signal voltage is developed across R52.

3.55 On positive half cycles, however, the situation is reversed and the detected voltage appears at the junction D17/R52 to drive the output emitter follower Q23. Under stable operating conditions this detected voltage has a level of 3.9V (reference) plus a mean level of approximately 0.5V for the superimposed positive half cycles. This 4.4V signal is supplied to the a.l.c. feedback path where R54 (with R2/R3) attenuates it to a mean 3.9V level.

3.56 The detected signal, described in the previous paragraph, is also fed from the emitter of Q23 to the A.M. Calibration potentiometer R53 and to the Function switch (on A.M. mode) thence to the first a.f. amplifier.

3.57 F.M. Discriminator. Transistors Q9/Q10 with Q12 are arranged as a limiting amplifier which saturates when driven by the constant i.f. signal, thus providing a square wave output at Q12 collector.

3.58 The d.c. supply is 10V and potential divider R25/R26 ensures that the base of Q9 is biased to +5V, therefore with no external signal applied the base of Q10 will acquire a mean level of +5V. When a signal is applied the output at Q12 collector (TP6) will be a square wave with 1:1 mark/space ratio, a mean level of +5V and peak to peak amplitude of approximately 9V.

3.59 The significant components of the F.M. Discriminator are Q14, R34, C24, D7 and Q15. Transistor Q14 is a saturating amplifier driven by the square wave output from Q12 and thus switches on and off at the frequency of the i.f. signal. When Q14 is conducting it draws a charging current through D7 into C24.

3.60 When Q14 turns off the junction R34/C24 attempts to rise to +7V. This voltage is effectively added to the stored voltage in C24 and thus forward biases the base-emitter junction of Q15, which allows the stored charge in C24 to be transferred to the

collector circuit of Q15. The output from Q15 therefore consists of a succession of current pulses at the switching frequency of Q14. This pulse type output is filtered by C26 in the amplifier Q16/Q17, the mean output voltage being determined by R38.

3.61 Since the quantity of energy stored in C24 in a given time period is proportional to the switching frequency of Q14, it follows that the mean voltage at the output of the amplifier Q16/Q17 will be proportional to the frequency of the i.f. and hence will vary according to the frequency deviation. From Q17 the output is fed via a calibrating potentiometer R42 to the F.M. position of the Function switch.

+7V Rail Stabilization

3.62 A stable +7V supply is essential to ensure a constant rate of charge in C24 for F.M. detection. Transistors Q18 and Q19 form the stabilizer circuit which functions on conventional lines; the diodes D8 to D11 provide temperature compensation which ensures stable performance in the f.m. discriminator.

A.F. Circuits

3.63 From the Function switch the detected signal, either a.m. or f.m., is fed through the amplifying and filtering stages associated with Q24/Q25, Q26 and Q27. From Q27 the audio signal is fed either through the unity-gain inverting amplifier Q28/Q29 (TROUGH selected) or direct via the PEAK position of switch S5 to the A.F. Filter and Range attenuation network.

3.64 A.F. Filter Switching. In the OUT position of the A.F. Filter switch S6, the signal path is via R76, R78 and switch contact S6b to the Meter Range switch S2. High frequency lift (to compensate for "droop" in preceding i.f. filters) is provided by C41 and further i.f. filtering by C44 and C47 in series.

3.65 With the A.F. Filter switch at IN both R78 and C44 are by-passed by the switch. This gives a filter which peaks at 1kHz and is 3dB down at 300Hz and 3kHz. Beyond these points the signal attenuation becomes 6dB per octave.

3.66 A useful feature of the a.f. filter is that at 1kHz there should be no significant change in output level between the IN and OUT positions of the A.F. Filter switch.

Meter Range Attenuator

3.67 The adjacent settings of the Meter Range switch (3, 10, 30, 100) have a 10dB relationship, these 10dB attenuation steps being provided by the network R77 and R79-R85. The front panel toggle switch S4 (referred to as the Meter Scale switch) follows the Meter Range selection and can add either 0dB (1.5-50 position) or a further 6dB of attenuation (3-100 position) thus effectively giving eight ranges to the Meter Range switch.

2nd A.F. Amplifier

3.68 From the Range Attenuator the a.f. signal is fed via switch S4 to the amplifier Q30/Q31/Q32. This is a high gain virtual earth amplifier with d.c. coupling. From the junction of R95/R96 an audio output at 600 ohms impedance is supplied to the rear panel outlet (SK8).

3.69 The diode D18 is an interesting design feature. Its purpose is to ensure that the output meter gives a hard-over deflection if the instrument is overloaded by too high an input level. Without the diode an overloading signal would cause distortion, leading to self-biasing and a meter reading of less than full scale, which could be mistaken for a normal reading.

Peak Detector and Meter

3.70 The peak detector is Q34 which conducts on positive peaks and maintains the charge on the reservoir capacitor C54. The discharge path for C54 is through R100, the "Set Meter" potentiometer R101 and the meter itself.

3.71 The peak detector Q34 is biased to the threshold of the conducting state to ensure that the lowest scale readings are peak detected accurately. The bias and temperature compensation for Q34 is provided by Q33 and R97 via R98. The sensitive condition of the peak detector accounts for the small meter reading which may be seen under 'no signal' conditions.

3.72 The peak detector output is available for external use at the D.C. OUTPUT socket on the rear panel. The source impedance is nominally 10k ohm as determined by R103 and R102.

3.73 The meter receives the peak detector output in the A.M. and F.M. positions of the Function switch. In the TUNE position the meter is connected to the oscillator tuning loop to provide a manual tuning indication.

3.74 The BATTERY CHECK switch S3 is spring-loaded to maintain the meter connection to the Function switch; by holding down this switch the meter may be used to check the battery voltage. This check can be made only with the batteries under load (i.e. instrument POWER switch to ON). If the a.c. supply is connected no reading can be obtained.

POWER SUPPLY AND BATTERY CHARGING SYSTEM

Introduction

3.75 The power supply rectifiers, with the stabilizing and battery charging circuit are mounted on the main p.c.b. The circuit details are in Fig. 4 at the back of the book. Details of the a.c. supply connection and power transformer tappings are shown in the interconnection diagram Fig. 8.

Stabilizing Circuit

3.76 The rectifier and stabilizing circuits operate on conventional lines but with additional protection for the battery. The output of the bridge rectifier D151-D154 is smoothed by the reservoir C1 (which is mounted on the side member). The rectified output is regulated by the power transistor Q1 controlled by Q154 and the long-tailed pair Q152/Q153. One side of the pair is referenced to the zener diode D155 whilst the other side (Q153) senses the output voltage in the potential divider R161/R162/R163. The stabilized level is preset by R162.

3.77 An automatic power cut-off operates if supply voltages are too low. If a very low mains supply is connected, the regulating transistor Q1 may saturate, possibly causing false readings. Alternatively, if the instrument is being operated from batteries it is desirable not to discharge the batteries completely, but to disconnect them if they are approaching the discharged condition. If either of these power conditions occurs the series regulator Q1 will automatically be turned off, thus cutting off the power to the remainder of the instrument. This protection is carried out by Q151 and D156.

3.78 Normally, Q151 will be held on by the voltage on zener diode D156, but if the voltage at the junction R152/R153 falls below the critical level D156 will switch off, thus turning off Q151 and the long-tailed pair. This will cause Q1 to be turned off, thereby cutting off the d.c. supply to the instrument.

Battery Charging System

3.79 Two battery charging modes have to be considered:-

(a) A trickle charge when the POWER switch is ON.

(b) A full rate of charge when the POWER switch is set to CHARGE.

3.80 Trickle Charge. Referring to the circuit Fig.4 , when the POWER switch S8 is at ON the negative supply rail is connected via current limiting resistor R167 to pin 36 of the p.c.b., thence via the ON contact of switch S8a to the negative terminal of the battery.

3.81 Full Charge Rate. The full rate charging path is via current sensing resistors R165/R166 in parallel, through diode D157 and the CHARGE contact of switch S8a to the negative terminal of the battery. The regulating system is switched to a higher output voltage by switching R168 in parallel with R161/R162 via the CHARGE contact of switch S8b, thus altering the value of the voltage sensing potentiometer. The charging current is controlled at approximately 0.4A by applying the voltage developed across R165/R166 to the base of Q156.

Power 'Off' on Battery Operation

3.82 When the a.c. supply is not connected to a battery-operated instrument the CHARGE position of the POWER switch S8 serves as the instrument 'off' switch. This is

arranged by diode D157 which is reverse-biased when no negative voltage is present on the cathode side.

Battery Metering Control

3.83 It is arranged that a battery voltage reading can only be obtained when:-

(a) The a.c. supply is disconnected

and

(b) The POWER switch is set to ON.

These conditions are automatically enforced by transistor Q157 together with diodes D158 and D159, as follows.

3.84 Transistor Q157 is in shunt with the meter connections and will be held in a conducting state via R169 when battery metering is to be inhibited. When, however, the POWER switch is set to ON and the a.c. supply is disconnected, the negative battery voltage will be applied via switch contact S8a, pin 36 and D159 to the base of Q157, thus turning off Q157 and removing the shunt from the meter BATTERY CHECK connections.

3.85 When the a.c. supply is connected the trickle charge current through R167 will produce a volt drop which will make the cathode of diode D159 more positive than the emitter of Q157, thus allowing Q157 to conduct and maintain the inhibit on the BATTERY CHECK metering.

CHAPTER 4

MAINTENANCE

INTRODUCTION

4.1 This chapter contains information grouped as follows:-

(a) List of Test Equipment (Page 4-2)

(b) Power Supply Check, both mains and battery versions. (pages 4-3 to 4-8)

(c) Calibration Check. (Page 4-9)

(d) Setting up of the automatic tuning and frequency control system. (Pages 4-11 to 4-14)

(e) Checking of the measurement circuits for serviceability. (Pages 4-11 to 4-20)

(f) Fault Diagnosis. (Page 4-21)

CALIBRATION

4.2 This chapter will assist the user in maintaining the instrument to a serviceable standard. With measurement instruments, however, a periodic calibration check is advised, and such checks must be made against an accurately calibrated modulation reference. It is recommended therefore that calibration of the 9009 be entrusted to Racal Instruments Ltd or authorized Racal agent.

REMOVAL OF TOP OR BOTTOM COVER

4.3 (1) Switch the instrument POWER switch to CHARGE and switch off the a.c. supply at the bench outlet. Unplug the power lead from the rear panel of the instrument.

(2) Remove the rubber bungs (located near to the rear end) from both side panels of the instrument and slacken, by about two turns, the screws revealed.

(3) Grip the rear panel assembly and ease it back from the main case to the maximum extent available (about 5mm).

(4) The rear edge of either cover can now be lifted and the cover withdrawn outwards and rearwards.

(5) To replace the covers reverse the above procedure.

TABLE 4.1 LIST OF TEST EQUIPMENT REQUIRED

Description		Details	Preferred Type
1	Multimeter	20 kilohm/V. AC/DC 0-250V d.c. 0-1A Accuracy 2% f.s.d.	AVO 8 Mk II
2	AM/FM Signal Generator (U.H.F.)	Range 5MHz to 1GHz Output 1V r.m.s. (50 Ω) Low noise specification	Hewlett Packard HP8640 & Frequency Doubler
3	Signal Generator (For External Osc. check only)	Range 20MHz to 30MHz Output 100mV to 1.2V r.m.s. (50 Ω)	HP.608E or HP.3200B
4	Oscilloscope (including x 10 probe)	Bandwidth d.c. - 50MHz Sensitivity 10mV/cm.	Tektronix 453 or HP.180A
5	Frequency Meter (Counter)	Range 10Hz - 30MHz ± 1% Sensitivity 10mV High impedance input	Racal 9822 or Racal 9837 or Racal 9838
6	Millivoltmeter	Range 50mV - 2V r.m.s. Input impedance > 100k Freq. range 50Hz - 1MHz	Marconi TF2600 HP.400E
7	High Impedance D.C. Voltmeter	Range 0-20V Accuracy better than 1%	Racal 9076 Digitec 2115
8	Harmonic Distortion Meter	Range 30Hz - 10kHz (fundamental) Distortion Level < -55dB	HP.333A
9	Regulated Power Supply	Range 0-20V d.c. Rating: 1A	Farnell L30B
10	Miscellaneous:- Resistor Termination 'T' Piece Coaxial leads	 33 Ω 5W 5% 600 Ω on BNC plug BNC (2 female, 1 male) BNC to BNC: 1 at 0.5 metre length 2 at 1 metre length	

POWER SUPPLY PREPARATION

CAUTION: With covers removed, and mains power connected, dangerous a.c. voltages are exposed.

Voltage Selection

4.4 Mains voltage selection is by means of soldered links on four terminals within the instrument, adjacent to the power transformer. The instrument is normally dispatched from the factory with a 230V selection. If the links are changed to the 115V position an adhesive label indicating '115V' must be affixed to the rear panel.

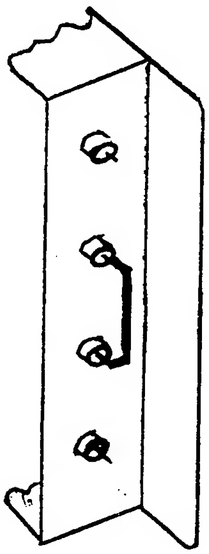
(1) Switch the instrument POWER switch to CHARGE (off) and switch off the a.c. supply at the bench outlet. Unplug the power lead from the rear panel of the instrument.

(2) Remove both covers (refer to para. 4.3).

(3) Remove completely the two side screws which were slackened when removing the covers.

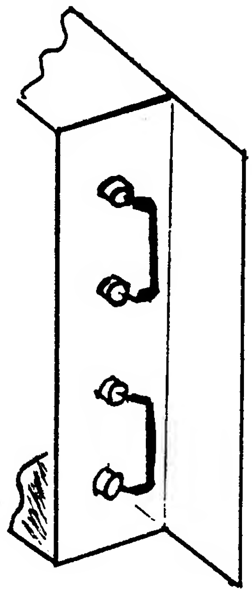
(4) Withdraw the rear panel rearwards until it is free of the side-plates, then tilt the panel backwards to expose the power connection terminals shown in Fig. 4.1 below.

(5) Refer to Fig. 4.1 below and verify that the soldered link(s) are correctly set for the local a.c. supply voltage.



Link for Nominal 230V A.C. Supply.

Fig. 4.1.



Links for Nominal 115V A.C. Supply.

Fuse Check

4.5 (1) A.C. Power Fuse. The correct rating is as follows:-

Supply	Rating	Part No.
200 - 250V	80mA antisurge	23-0029
100 - 125V	160mA antisurge	23-0019

(2) D.C. Fuse

Rating		
500mA	Normal quick action	23-0004

This fuse is located on the underside at the rear of the large p.c.b., adjacent to the mains transformer. A ready symptom of d.c. fuse failure is given if the MAINS warning lamp is 'ON' but the IN LOCK lamp fails to illuminate when the POWER switch is 'ON'.

Power Lead

4.6 Fit a suitable plug to the power lead supplied, in accordance with the standard colour code:-

Brown	Line
Blue	Neutral
Green/Yellow	Earth (ground)

Battery Pack Mounting Kit (Part of Option 07)

4.7 If an instrument has not previously been fitted with a battery pack it may be necessary to fit the two location pegs and the mounting bracket to the inner faces of the chassis side plates. These items are supplied with the Battery Option kit. Proceed as follows:-

(1) Remove the instrument bottom cover. (Para. 4.3).

(2) Place the instrument with bottom side uppermost.

(3) Viewing the instrument from the front, offer the angle bracket to the right hand side plate with the narrow flange facing upwards.

(4) Register the holes in the larger flange with the two threaded apertures in the side plate. Insert the cross-head screws with crinkle washers supplied, and tighten up.

(5) In the opposite sideplate insert the two slot headed pegs with plain washers into the threaded apertures and tighten up.

(6) The battery pack in its metal cradle may now be fitted as described in the next paragraph, using the two screws, two solid washers and two crinkle washers supplied.

FITTING THE BATTERY PACK (OPTION 07)

NOTE 1: In earlier versions of the instrument battery connections are by soldered leads and the connections procedure is as detailed below. Later models employ a plug and socket connection system and operation (4) does not apply.

NOTE 2: If the instrument is not fitted with the battery pack mounting flange reference should be made to the preceding paragraph.

CAUTION: When connecting or disconnecting a battery pack it is essential that the a.c. supply be disconnected and the internal d.c. fuse removed. Great care must be taken to avoid inadvertent contact between battery pack and main p.c.b. which might cause destructive short circuits. Soldering of connecting leads (in the earlier models) must be carried out in the order given below.

Fitting Procedure

4.8 (1) Set the POWER switch to CHARGE and unplug the a.c. supply lead.

(2) Remove the bottom cover of the instrument (para.4.3).

(3) Remove the d.c. fuse.

(4) Earlier Models

Remove any insulating protection from the ends of the battery leads and solder the positive battery lead to pin 30, located near the centre of the rear edge of the main p.c.b. Solder the negative battery lead to pin 33 on the main p.c.b.

(5) Later Models

In later models the battery leads are fitted with connectors which fit onto pin 30 (+) and pin 33 (-) on the p.c.b. The polarity of the battery leads is identified by a red sleeve (or, alternatively, a sleeve marked '+') for the positive connection and a black sleeve (or a sleeve marked '-') for the negative connection.

(6) Replace the d.c. fuse.

(7) Place the instrument on its right hand side.

(8) Offer up the battery pack to the underside of the instrument, with the batteries facing inwards and the end flange of the Pack resting on the right hand (lower) side of the instrument.

(9) Taking care to avoid trapping of the leads, fit the holes in the battery pack end flange on to the projecting pegs on the lower side panel of the instrument.

(10) Hold the battery pack in position and carefully turn the instrument bottom upwards.

(11) Secure the battery pack to the bracket using the two screws with plain and crinkle washers provided.

(12) Stow the connecting leads and refit the bottom cover.

(13) Carry out the battery check (para. 4.9).

BATTERY CHECK

4.9 If the optional battery pack is fitted, it may be checked as follows:-

(1) Disconnect the a.c. supply.

(2) Set the POWER switch to ON and allow approximately 2 minutes before taking the Battery Check reading.

(3) Hold the BATTERY CHECK switch in the 'down position', at the same time verify that the meter reading is within the green portion of the meter scale. If the meter reading is below the green portion of the scale re-charging is necessary.

(4) To re-charge, connect up the a.c. supply and set the POWER switch to CHARGE. The full charging period is approximately 14 hours, but no damage can result if the batteries are allowed to charge for a period up to 48 hours maximum. Persistent over-charging beyond 48 hours may reduce the battery charge capacity.

BRIEF FUNCTIONAL CHECK

4.10 (1) Connect up the power supply and check that the MAINS indicator lamp is illuminated.

(2) Set the POWER switch to ON. If battery operated, check battery voltage (see para. 4.9).

(3) Set the AUTO switch to AUTO and the FUNCTION switch to A.M.

(4) Verify that the IN LOCK lamp is flashing.

(5) Apply a suitable a.m. signal within the 'Auto' frequency range to the appropriate input socket.

(6) Check that the IN LOCK lamp changes to a steady illumination. If it fails to do so check that:-

(i) Input signal amplitude is within the specification range for the input socket in use.

(ii) That the input frequency is within the 'Auto' range.

(7) Verify that the meter reading is correct for the signal applied.

(8) Select F.M. on the FUNCTION switch.

(9) Repeat (6) and (7) with an f.m. signal input.

DETAILED POWER SUPPLY CHECKS

MAINS INPUT RESISTANCE

4.11 (1) DO NOT plug in the mains supply, but check that mains power fuse is fitted.

(2) Using a multimeter measure the resistance between the 'Line' and 'Neutral' pins of the rear panel mains connector. With the transformer tappings set to the nominal 230V range verify a resistance reading of 300 ohms $\pm$ 50 ohms.

D.C. SUPPLY REGULATOR CHECK

4.12 (1) DO NOT plug in the mains supply.

(2) Set instrument Power switch to CHARGE and AUTO/EXT switch to AUTO.

(3) Remove the 500mA d.c. fuse (FS1) from the Motherboard 19-0751 and connect the multimeter (set to 10A range) across the fuseholder of FS1.

(4) Plug in the a.c. mains supply but keep the POWER switch at CHARGE. Verify that the MAINS ON lamp is illuminated.

(5) Reduce the multimeter range setting from '10A' to '100mA', at the same time verifying that the current reading remains between 50mA (maximum) and 40mA (minimum). Return the multimeter range to '10A' and maintain the connections.

(6) Connect a d.c. voltmeter +ve lead to pin 30 on the Motherboard (-ve lead to 0V).

(7) Set potentiometer R162 fully anticlockwise and verify a voltmeter reading of 15.8V ± 1V. Leave all meters connected.

(8) Switch from CHARGE to POWER ON and check that the multimeter (current) reading does not exceed 350mA.

(9) Check that the voltmeter reading at pin 30 has dropped to 9.1V ± 0.5V.

(10) Adjust potentiometer R162 to set the voltage at pin 30 to 10V ± 0.1V.

(11) Disconnect the multimeter and fit the 500mA d.c. fuse.

BATTERY OPERATION AND CHARGING CHECK

NOTE: A regulated variable d.c. supply must be available for the Battery Operation check. The D.C. Supply Regulator Check (see previous para.) must be satisfactorily completed first.

4.13 (1) Check that batteries are removed from the instrument and mains supply disconnected.

(2) Set the front panel controls as follows:-

(a) A.F. FILTER to OUT.

(b) PEAK/TROUGH switch to TROUGH.

(c) FUNCTION Switch to A.M.

(d) METER RANGE switch to '100': Meter Scale switch '3-100'.

(3) Set the regulated d.c. supply to +12.5V and connect to the battery input socket (pins on earlier models), being careful to observe correct polarity.

(4) Connected a d.c. voltmeter to pin 30 of the Motherboard.

(5) Switch to POWER ON and check that the voltage at pin 30 is 10V ± 0.1V. If necessary adjust R162 on the p.c.b. to obtain this reading.

(6) Slowly reduce the voltage of the regulated d.c. supply until the level at pin 30 falls to between 5V and 7V.

(7) Using the d.c. voltmeter, verify that the voltage across capacitor C1 (mounted on the side panel) is 10V ± 8V.

(8) Hold down the BATTERY CHECK switch and raise the input voltage to the point where the instrument meter indication is at the lower edge of the green band.

(9) Again check the voltage across C1, which should be 11V ± 0.2V.

(10) Disconnect the regulated d.c. supply unit and in its place connect a 33 ohm 5 watt resistor in series with a multimeter set to the 1A range. (Positive lead to pin 33 of the Motherboard.)

(11) Connect the mains supply and measure the voltage on pin 30 which should now read 10.1V ± 0.1V.

(12) Hold down the BATTERY CHECK switch and check that the front panel meter reads zero.

(13) With the POWER switch at ON, and the multimeter connected as in (10) and set to the 100mA range verify a reading of 65mA ± 10mA.

(14) Switch the POWER switch to CHARGE and the multimeter to the 1A range. Verify a multimeter reading of 400mA ± 50mA. (In some instances the multimeter may continue to indicate about 30mA. If so, briefly remove and replace the meter lead. This should change the current to the correct value.)

CALIBRATION CHECK

NOTE: The following test constitutes a basic serviceability check on the instrument. If satisfactory results are not obtained refer to the Assembly Setting up procedures, commencing on page 4-11.

Equipment Required

4.14 (a) High quality A.M./F.M. Signal Generator. (Table 4.1 Item 2).

4.15 Procedure

NOTE: With a battery operated instrument check for satisfactory battery voltage before commencing the test.

(1) Set the 9009 controls as follows:-

(a) AUTO/EXT OSC. switch to AUTO.

(b) FUNCTION to F.M.

(c) METER RANGE switch to '100': Meter Scale switch '3-100'.

(d) AF FILTER switch to IN.

(2) Set the signal generator to F.M. 1kHz modulation and apply a 10MHz signal at 100mV r.m.s. to the 'Low Level' (150mV MAX) input socket of the 9009.

(3) Referring to Table 4.2 below, set the signal generator to the peak deviations and the METER RANGE and Meter Scale switches to the related positions. Verify that the correct meter indications are obtained.

TABLE 4.2

Signal Generator Peak Deviation	Meter Range and Scale Switches	Meter Scale Reading
100kHz	'100' & '3-100'	10 (f.s.d.) ± 0.1
50kHz	'100' & '3-100'	5 ± 0.2
30kHz	'100' & '3-100'	3 ± 0.15
10kHz	'100' & '3-100'	1.0 ± 0.15
50kHz	50 & 1.5-50	5 (f.s.d.) ± 0.1
15kHz	15 & 1.5-50	1.5 (f.s.d.) ± 0.1
5kHz	5 & 1.5-50	5 (f.s.d.) ± 0.1
1.5kHz	1.5 & 1.5-50	1.5 (f.s.d.) ± 0.1

(4) Switch both the signal generator and the 9009 FUNCTION switch to A.M. Refer to Table 4.3 below and check the meter indication for the modulation depths listed.

TABLE 4.3

Modulation Depth	Meter Range and Scale Switches	Meter Scale Reading
90%	'100' & '3-100'	9.0 ± 0.1
30%	'30' & '3-100'	3.0 (f.s.d.) ± 0.1

ASSEMBLY SETTING-UP PROCEDURES

Local Oscillator (V.C.O.) Calibration

4.14 Equipment Required

(a) Regulated variable d.c. power supply. (Table 4.1 item 9).

(b) Digital Frequency Meter (30MHz). (Table 4.1 item 5).

(c) D.C. Voltmeter. (Table 4.1 item 1).

4.15 Procedure

(1) Switch the POWER switch to CHARGE.

(2) On the Motherboard disconnect the link LK1 from between pins 55 and 56.

(3) Connect the Regulated D.C. Power Supply +ve lead to pin 56 of the Motherboard (-ve lead to 0V) and apply 7V (± 0.1V). Monitor this voltage with the d.c. voltmeter.

(4) Connect the Frequency Meter to pin 5 on the Sampling Mixer P.C.B., 19-0742.

(5) Connect the mains supply and switch to POWER ON.

(6) On the Motherboard adjust the core of L203 for a readout of 27.0MHz on the frequency meter.

(7) Change the applied voltage at pin 56 to +2.8V (± 0.1V) and check that the frequency readout falls to lower than 20.0MHz.

(8) If continuing with subsequent tests maintain link LK1 disconnected and +2.8V applied to pin 56. Otherwise reconnect the link and remove d.c. supply.

Sampling Mixer P.C.B. 19-0742

4.16 Equipment Required

(a) Signal Generator (10MHz). (Table 4.1 item 2).

(b) Oscilloscope with x 10 Probe. (Table 4.1 item 4).

(c) Regulated D.C. Power Supply. (Table 4.1 item 9).

NOTE: For convenience the signal input sockets on the front panel will be identified as Low Level for the "150mV Max" and High Level for the "1V Max" socket.

4.17 Procedure

(1) If not already done, remove link LK1 and apply +2.8V to pin 56 of the Motherboard as in the previous test.

(2) Apply a 10MHz, 100mV r.m.s., signal to the front panel 'Low Level' input.

(3) Switch to POWER ON and using an Oscilloscope with x 10 probe monitor the i.f. output on pin 3 of the Sampling Mixer P.C.B.

(4) Check that a "zero beat" condition can be obtained by slightly varying the input (signal generator) frequency.

(5) Change the signal generator frequency to 15MHz at 100mV r.m.s. and check that the displayed waveform resembles a 100% A.M. signal.

(6) Check that the displayed amplitude is not less than 400mV peak-to-peak.

(7) Reduce the signal generator frequency from 15MHz to a frequency at which an i.f. of approximately 500kHz is displayed on the oscilloscope.

(8) With an input level of 100mV r.m.s. verify that the amplitude of the i.f. is not less than 400mV peak to peak.

(9) If continuing with subsequent tests maintain signal generator input, LK1 disconnected and 2.8V applied to pin 56. Otherwise reconnect the link and remove the d.c. supply.

Motherboard P.C.B.: Discriminator and Hunt Generator Check

4.18 Equipment Required

(a) Digital Frequency Meter. (Table 4.1 item 5).

(b) Oscilloscope with x 10 probe. (Table 4.1 item 4).

(c) Signal Generator. (Table 4.1 item 2).

(d) D.C. Voltmeter. (Table 4.1 item 7).

(e) Regulated D.C. Power Supply. (Table 4.1 item 9).

4.19 Procedure

(1) Maintain the test conditions stipulated in operation (9) of the previous test.

(2) On the Motherboard set R9 fully anticlockwise.

(3) Monitor test point TP15 with the digital frequency meter and set the i.f. to 500kHz ($\pm$ 2kHz) by fine adjustment of the signal generator frequency.

(4) Using the d.c. voltmeter verify a level of 5.3V $\pm$ 0.5V at TP16.

(5) Transfer the d.c. voltmeter to TP18 and, by adjustment of R295, obtain the same reading as in (4) above.

(6) Check that the IN LOCK lamp has steady illumination. If it is flashing reduce the i.f. to less than 100kHz. The indicator should then change to steady illumination.

(7) Slowly adjust the signal generator to increase the frequency of the i.f. to approximately 700kHz on the frequency meter. Check that the IN LOCK lamp maintains steady illumination during this change. Continue increasing the i.f. until the IN LOCK lamp commences to flash.

(8) Connect the Oscilloscope to pin 55 on the Motherboard. Select a timebase of 0.5s/div. Check for a triangular waveform display of period 1.4 seconds, $\pm$ 0.5 seconds.

(9) Check that the voltage range of the triangular waveform is from 2.25V $\pm$ 0.25V to 7.5V $\pm$ 0.5V.

(10) By adjustment of the signal generator slowly reduce the frequency of the i.f. to 300kHz and note that the IN LOCK lamp continues to flash. Continue to reduce the frequency until a steady illumination is obtained.

(11) For the next test maintain the signal generator input, link LK1 disconnected, +2.8V applied to pin 56 and digital frequency meter connected to TP15.

Motherboard P.C.B.: Low Level Detector

4.20 (1) Check that the test conditions of item (11) in previous test are maintained.

(2) Adjust the signal generator so that the frequency of the i.f. at TP15 is 500kHz ($\pm$ 20kHz). Check that the IN LOCK lamp shows steady illumination.

(3) Slowly reduce the input signal voltage and note the level at which the IN LOCK lamp commences to flash. This level should be 7mV (+0.0mV, -5.0mV).

(4) Switch the instrument to CHARGE. Disconnect the frequency meter and the d.c. voltmeter. Remove the d.c. voltage from pin 56.

(5) Resolder the wire link between pins 55 and 56.

Motherboard P.C.B.: Frequency Control Loop

4.21 Equipment Required

(a) U.H.F. Signal Generator. (Table 4.1 item 2).

(b) Digital Frequency Meter. (Table 4.1 item 5).

4.22 Procedure

(1) Switch to POWER ON.

(2) From the Signal Generator apply 12MHz at 100mV r.m.s. to the LOW Level input socket.

(3) Check that the IN LOCK lamp shows steady illumination.

(4) Connect the frequency meter to TP15 and adjust potentiometer R295 on the Motherboard for an i.f. of 500kHz (± 5kHz).

(5) Change the 100mV input signal to 9.5MHz. Check that the i.f. readout remains at 500kHz (± 5kHz) and IN LOCK illumination is steady.

(6) Very slowly reduce the input frequency, (but do NOT allow the frequency of the i.f. readout to exceed 600kHz). Note the input frequency at which the IN LOCK indicator commences to flash. This should be not higher than 9.0MHz.

(7) Very slowly increase the input frequency until the IN LOCK indicator resumes steady illumination. Check that the input frequency is not higher than 9.5MHz at this point.

(8) Set the 100mV input signal to 13.3MHz and check that the IN LOCK lamp maintains steady illumination.

(9) Refer to Table 4.4 below.

(a) Apply the listed frequencies first to the Low Level input socket and record the minimum input level at which steady IN LOCK illumination can be maintained.

(b) Repeat the tests on the High Level input socket and verify that the level in each case is 20dB higher than that measured with the Low Level input.

TABLE 4.4

Input Freq. (MHz)	Minimum Input Level for steady IN LOCK		
	"Low Level" I/P	Relative "High Level" I/P	
12	8mV	+ 20dB	± 2dB
50	8mV	+ 20dB	
300	8mV	+ 20dB	
500	8mV	+ 20dB	± 3dB
750	13mV	+ 20dB	
1000	18mV	+ 20dB	

MEASUREMENT PERFORMANCE

INTRODUCTION

4.23 The following tests apply to the measuring circuits of the instrument. Before making these tests it is essential that the power supply and frequency control loop be checked for serviceability in accordance with preceding paragraphs.

IMPORTANT NOTE:

Tests in the measurement section of the instrument are valid only if carried out using a signal generator with relevant performance specification at least equal to the 9009. This applies particularly to low noise content and accuracy of modulation. For a complete calibration service the user is advised to contact Racal Instruments Ltd or an authorized Racal agent.

TEST PROCEDURES

I.F. and A.F. Output Levels

4.24 Equipment Required

(a) AM/FM Signal Generator (see NOTE above).

(b) Oscilloscope. (Table 4.1 item 4).

(c) A.C. Millivoltmeter. (Table 4.1 item 6).

(d) BNC to BNC Coaxial lead (0.5m).

(e) BNC 'T' Piece with 600 ohm termination.

4.25 Procedure

(1) With instrument switched to CHARGE set the meter mechanical zero.

(2) Set the 9009 controls as follows:-

(a) AUTO/EXT OSC switch to AUTO.

(b) FUNCTION switch to FM.

(c) METER RANGE switch to '100': Meter Scale switch to '3-100'.

(d) AF FILTER switch to IN.

(e) PEAK/TROUGH switch to -/TROUGH.

(3) Set the signal generator as follows:-

(a) 10.6MHz output at 100mV r.m.s.

(b) F.M. Mode.

(c) Modulation frequency: 1kHz.

(d) Peak Deviation: 100kHz.

(4) Connect the signal generator output to the 'Low Level' (150mV MAX) input socket of the 9009 and switch to POWER ON.

(5) Connect the oscilloscope to the I.F. output socket on the rear panel of the 9009 using the coaxial lead.

(6) Check that the oscilloscope displays a nominal 500kHz sinewave with no obvious distortion.

(7) Connect an a.c. millivoltmeter in place of the oscilloscope. Verify an i.f. level (e.m.f.) of 100mV r.m.s. $\pm$ 15mV.

(8) Transfer the coaxial lead to the rear panel A.F. output socket and connect to the oscilloscope. Check that oscilloscope displays a nominal 1kHz sinewave.

(9) Connect the a.c. millivoltmeter in place of the oscilloscope and verify an a.f. level (e.m.f.) of 1V r.m.s. $\pm$ 0.01V. If necessary adjust R42 to obtain this reading.

(10) Check that the 9009 meter reads '10' (f.s.d. on the 0–10 scale). If necessary adjust R101 to set this reading to a tolerance of $\pm$ 0.05.

(11) Connect a 'T' piece with 600 ohm termination to the A.F. output socket. Verify a millivoltmeter reading of 500mV $\pm$ 25mV.

(12) Set the 9009 FUNCTION switch to A.M.

(13) Change the signal generator modulation to A.M., with modulation depth 90%.

(14) Verify that the 9009 meter reads '9', $\pm$ .05, on the 0–10 scale. If necessary adjust R53 to obtain this reading.

(15) Maintain signal generator input for the automatic level control test.

Automatic Level Control and A.F. Filter Check

4.26 (1) Maintain signal generator input and settings from the previous test and check that 9009 has a meter reading of '9'.

(2) Transfer the input signal to the 'High Level' (1V MAX) input socket and check that the meter reading does not change by more than 1% of full scale reading.

(3) Switch the signal generator to F.M. with 100kHz peak deviation.

(4) Switch the 9009 FUNCTION switch to F.M. and verify that the meter reads '10', $\pm$ 0.1.

(5) Transfer the input signal to the 'Low Level' input socket and check that the meter reading does not change by more than 1% of f.s.d. as the A.F.FILTER is switched from IN to OUT. Finally reset the A.F.FILTER to IN.

(6) Set the signal generator to the modulation frequencies in Table 4.5 below (maintain 100kHz peak deviation) and check for the corresponding meter readings.

TABLE 4.5

Modulation Freq.	Meter Reading
48Hz	1.9 ± 0.2
300Hz	8.0 ± 0.3
3kHz	8.0 ± 0.3
10kHz	3.3 ± 0.3

A.F. Frequency Response

4.27 (1). Set the controls of the 9009 under test and the Signal Generator, as in para. 4.25 operations (2) and (3).

(2) Refer to Table 4.6 below. Apply the listed modulation frequencies and check for variations in meter readings using the 1kHz reading as a reference.

TABLE 4.6

Modulation Freq.	9009 Meter Reading
1kHz	Reference (approx. f.s.d. on 0-10 scale)
48Hz	(Reference ± 0.3)
300Hz	(Reference ± 0.1)
3kHz	(Reference ± 0.1)
10kHz	(Reference ± 0.3)

(3) Set the 9009 FUNCTION switch to A.M. and switch the Signal Generator to A.M. with modulation depth 90%.

(4) Repeat the operation of Table 4.6, but note that the 1kHz reference will now read approximately 9 on the 0-10 scale.

Range Attenuator Check

NOTE: The following tests check the Range attenuator steps by reference to the f.s.d. reading, thus avoiding the requirement for an accurately calibrated modulation source.

Equipment Required

(a) FM Signal Generator (Table 4.1 item 2).

Procedure

(1) Refer to para. 4.25 and set up the 9009 and signal generator as in operations (1) to (4) except that input peak deviation must be 3kHz and the METER RANGE switch set to position '3'.

(2) On the signal generator adjust the peak deviation to obtain an exact full scale reading on the 0-3 meter scale of the 9009.

(3) Set the METER RANGE switch to position '10' and verify that the meter reading falls to '3' on the 0-10 scale.

(4) Increase the signal generator peak deviation to obtain a precise full scale reading on the 0-10 scale.

(5) Set the METER RANGE switch to position '30' and verify that the meter reading falls to '10' on the 0-3 scale.

(6) Again increase peak deviation to obtain a full scale reading on the 0-3 scale. Switch the METER RANGE to '100' and verify that the reading falls to '30' on the 0-10 scale.

(7) Adjust the signal generator peak deviation to 50kHz and adjust for a 'half-scale' reading on the 9009.

(8) Switch the Meter Scale switch to the '1.5-50' position and verify that the meter reading doubles to f.s.d. on the 0-10 scale.

A.F. Harmonic Distortion

NOTE: For this test the user must be certain that the signal generator modulation performance is not inferior to the specification of the 9009.

4.28 Equipment Required

(a) A.M. Signal Generator (see NOTE above).

(b) Total Harmonic Distortion Meter (Table 4.1 item 8).

4.29 Procedure

(1) Check that the 9009 controls are set as follows:-

(a) FUNCTION switch to AM.

(b) METER RANGE switch to '100': Meter Scale switch '3-100'.

(c) AF FILTER switch to OUT.

(d) PEAK/TROUGH switch to -/TROUGH.

(2) Set the signal generator as follows:-

(a) 10.6MHz at 50mV r.m.s.

(b) A.M. mode.

(c) Modulation frequency: 1kHz.

(d) Modulation Depth: to be set to 80% reading on the 9009 (see operation (3)).

(3) Connect the signal generator output to the "Low Level" input socket of the 9009 under test, and adjust the signal generator modulation depth control to give a reading of 8 on the 9009 meter.

(4) Connect the Total Harmonic Distortion meter to the rear panel AF OUTPUT socket. Set the signal generator to the modulation frequencies in Table 4.7 below and verify that the total harmonic distortion reading is more negative than -46dB.

TABLE 4.7

Modulation Freq. (A.M.)	Total Harmonic Distortion
48Hz	Better than -40dB
1kHz	
10kHz	

(6) Set the 9009 FUNCTION switch to FM and connect the signal generator to the 'High Level' input of the 9009.

(7) Set the signal generator to F.M. with 100kHz peak deviation.

(8) Refer to Table 4.8 below, and check the total harmonic distortion limits for the modulation frequencies listed.

TABLE 4.8

Modulation Freq. (F.M.)	Total Harmonic Distortion
	Better than:-
48Hz	-46dB
1kHz	-46dB
3kHz	-46dB
10kHz	-46dB

(9) Disconnect the Distortion Meter but retain the signal generator for the next check.

High Level Indication Setting

4.30 (1) Set the signal generator to 100MHz at 150mV output and connect to the 'Low Level' input socket of the 9009.

(2) Adjust the 'High Level' potentiometer R9 so that the IN LOCK lamp just commences to flash.

External Oscillator Input Check

4.31 Equipment Required

(a) Two signal generators (100MHz and 20MHz). (Table 4.1 Items 2 and 3)

(b) Digital Frequency Meter. (Table 4.1 Item 5)

4.32 Procedure

(1) Connect the following:-

(a) Signal Generator, set to 100MHz at 100mV, connect to 'Low Level' input.

(b) Signal Generator, set to 20.1 MHz at 100mV, connect to front panel EXT OSC socket.

(c) Digital Frequency Meter, to read 500 kHz, connect to rear panel I.F. OUTPUT socket.

(2) Set the AUTO/EXT. OSC. switch to EXT. OSC. and adjust the "external oscillator" signal generator to produce a 500 kHz readout on the digital frequency meter. Check that the IN LOCK lamp shows steady illumination.

(3) Set the FUNCTION switch to TUNE and check that the meter needle indicates on the triangle mark. If necessary, adjust potentiometer R235 to achieve this alignment.

(4) Change the level of the "external oscillator" signal generator to 1.0V r.m.s. and check that the meter indication in (3) does not change. If necessary re-adjust the signal generator frequency to maintain the 500 kHz i.f. readout.

(5) Disconnect the test equipment and reset the AUTO/EXT. OSC. switch to AUTO.

GENERAL FAULT LOCATION

INTRODUCTION

4.33 Successful fault diagnosis requires a good understanding of the circuit principles described in Chapter 3, supplemented by intelligent use of the check procedures given earlier in this chapter. The fault location advice which follows is offered as an aid to tackling the problem in the most effective way.

4.34 Convenient test information is provided by the data diagrams labelled 'A' to 'U', shown on the circuit diagrams Fig. 3, Fig. 6 and Fig. 7 at the back of the book. This data must, however, be interpreted with discretion. For example, if an instrument is hunting continuously it will render much of the test data irrelevant until the lock condition is achieved.

INITIAL DIAGNOSIS

4.35 It should be possible to isolate the cause of malfunction to one of four areas, such as:-

(a) Power Supply

(b) Input and Sampling Mixer

(c) Oscillator and Frequency-Locked Loop

(d) The Measurement Circuits

4.36 Functional Check

Carry out the check in para. 4.10 to establish that the instrument is faulty.

4.37 Power Supply and Related Levels

NOTE: Use a.c. mains supply rather than batteries, if possible.

(1) Check d.c. fuse on Motherboard.

(2) With POWER switch to ON and MAINS ON indicator illuminated, connect a multimeter + ve lead to pin 39 on the Motherboard (- ve to chassis) and verify a reading of 10V ± 0.3V.

(3) Transfer the multimeter + ve lead to test point TP18 on the Motherboard and verify a reading of + 5.3V ± 0.5V. (See para. 4.19 operations (4) and (5) for correct setting).

(4) For further investigation of the power supply refer to paragraphs 4.12 and 4.13. If the instrument will work on batteries but not on mains the a.c. fuse, transformer, bridge rectifier and smoothing capacitor should be checked.

4.38 I.F. Check and Loop Check

(1) Select AUTO operation and apply an unmodulated v.h.f. signal at 100mV to the Low Level input.

NOTE: An input frequency in the range 50 MHz to 100 MHz is recommended, as it ensures that the loop is given adequate search range, thus offering several opportunities for achieving lock.

(2) If the IN LOCK lamp is flashing it may indicate either:-

(a) That the input signal level is not correct.
or
(b) That there is no frequency lock.

(3) Refer to test data 'A' at TP15 (circuit Fig.6) and with an oscilloscope check for 500 kHz i.f. signal. Select various input frequencies and check that the i.f. correctly "follows" the change of input frequency. If this test is satisfactory the loop is operating correctly and check (4) may be omitted.

(4) Failure to obtain the 500 kHz i.f. at TP15 may be caused by the following:-

(a) Input fault. (Check Attenuator)

(b) Faulty Oscillator.

(i) Refer to circuit diagram, Fig.6, and make data checks 'F' and 'E'.

(ii) Check with external oscillator, if available.

(iii) Refer to Calibration check in para. 4.15.

(c) Sampling Mixer faulty (Refer to para. 4.17 and data checks in circuit diagram Fig.3).

NOTE: Tests on the pulse generator in the Sampling Mixer Assembly require a "Sampling" Oscilloscope. See para. 4.39.

(d) Fault in Frequency Locked Loop.

(i) Refer to test data on circuit Fig.6 and the test procedures in paragraphs 4.18 to 4.22. Note that test data 'D' in Fig.6 is applicable only when the circuit is hunting (input frequency varied).

(ii) For technical descriptions of the discriminator refer to para. 3.13 and for the hunt generator to para. 3.22 in Chapter 3.

Sampling Mixer Pulse Generator Check

4.39 Suitable types of Sampling Oscilloscope are:-

(a) Phillips PM3400 (50 ohm input).

(b) Hewlett-Packard Type 140A Main Frame with Sampling Amplifier 1411A, Sampling Head 1432A and Sampling Time Base 1424.

The test connections must be made via an attenuating probe made up as in Fig. 4.2 below, the oscilloscope measurement being made across the 47 ohm resistor using a short length of 50 ohm coaxial lead.

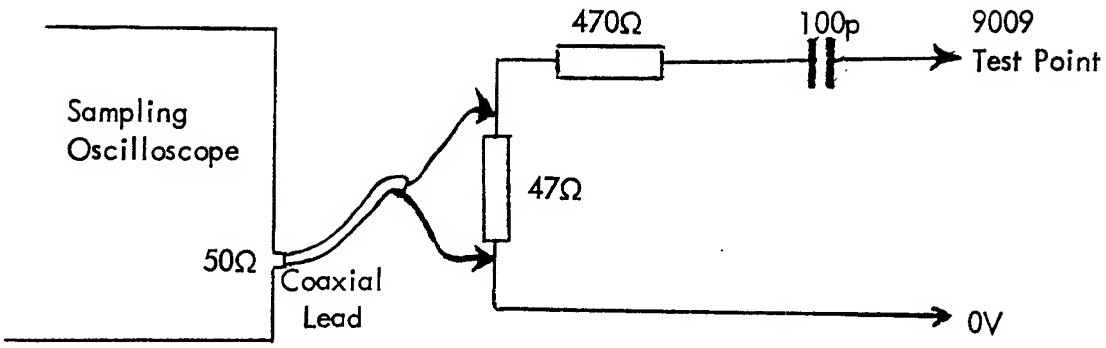


Fig. 4.2 Sampling Mixer Test Connections

NOTE: The voltages shown on the circuit diagram of the Sampling Mixer (Fig.3) are actual circuit voltages and do not allow for the attenuation in the probe.

4.40 Measurement Circuit Check

(1) Set up the instrument and carry out the I.F. check as in para. 4.25 operations (1) to (6).

(2) If the i.f. output at the rear panel outlet (SK4) is not obtained carry out data checks 'G' and 'H' (circuit diagram Fig.7) using an unmodulated input signal.

(3) If the i.f. output at SK4 is satisfactory continue signal tracing (checks 'J' to 'M' in Fig.7) using an unmodulated input signal to give clearest i.f. waveforms.

(4) Set the FUNCTION switch to A.M. Apply an amplitude modulated input signal and check for an a.f. signal at check points 'N' 'O' and 'P' in Fig.7.

NOTE: Some residual i.f. will be seen in test 'N'.

SECTION 3

PARTS LIST

CIRCUIT DIAGRAMS

AND

LAYOUTS

ORDERING OF SPARE PARTS

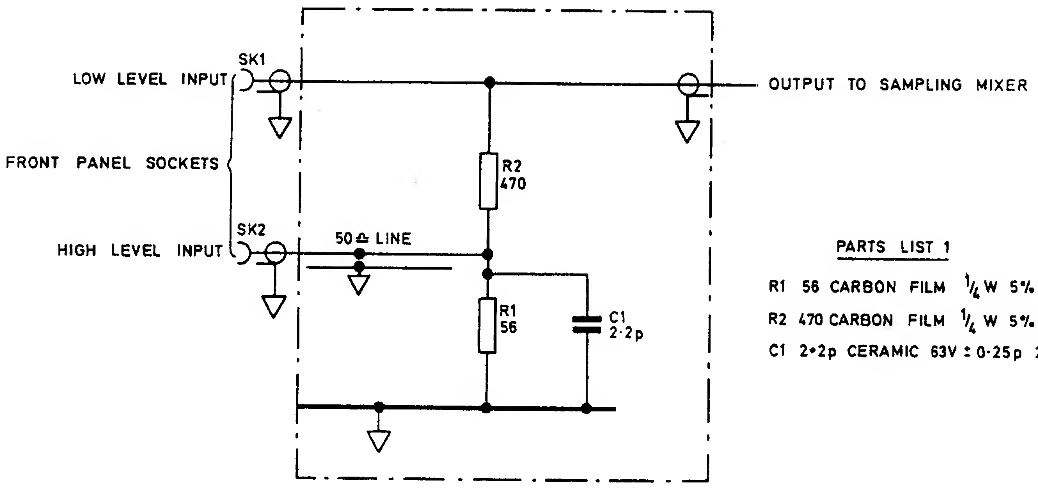
1. To be assured of satisfactory service when ordering replacement parts, the customer is requested to include the following information.

   (a) Instrument type and serial number.

   (b) The type reference of the Assembly in which the particular item is located.

   (c) The Part number and circuit reference of each item being ordered.

It should be noted that a minimum charge of £5 sterling is applicable to all U.K. orders.



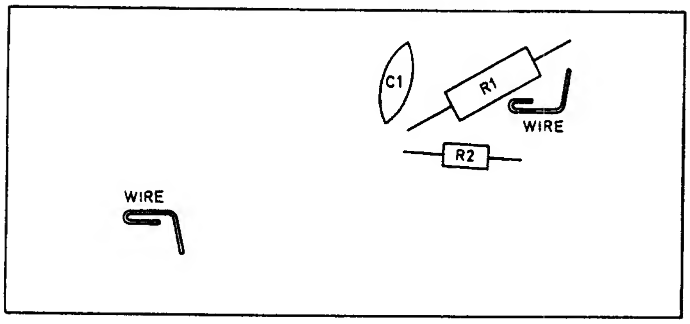
PARTS LIST 1

R1	56 CARBON FILM	1/4 W	5%	20-2560
R2	470 CARBON FILM	1/4 W	5%	20-1532
C1	2·2p CERAMIC	63V	± 0·25p	21-1672

19-0761/2
1

CIRCUIT

COMPONENTS ARE SOLDERED TO TRACK SIDE



19-0761/1
1

COMPONENT LAYOUT: TRACK SIDE

WOH4105

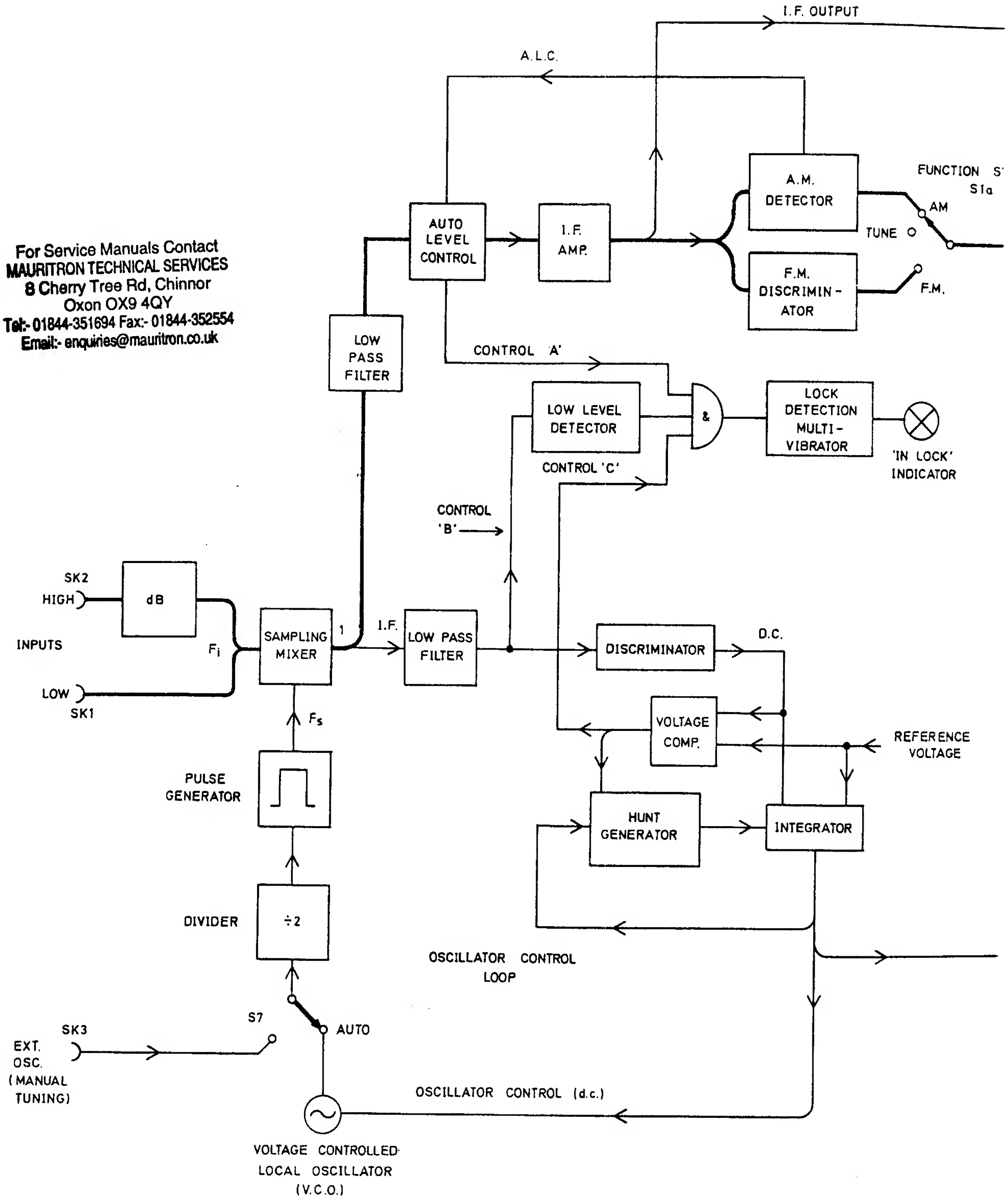
Circuit and Layout: Input Attenuator 19-0761

Fig. 1

COMPONENTS IN FIGURE 3

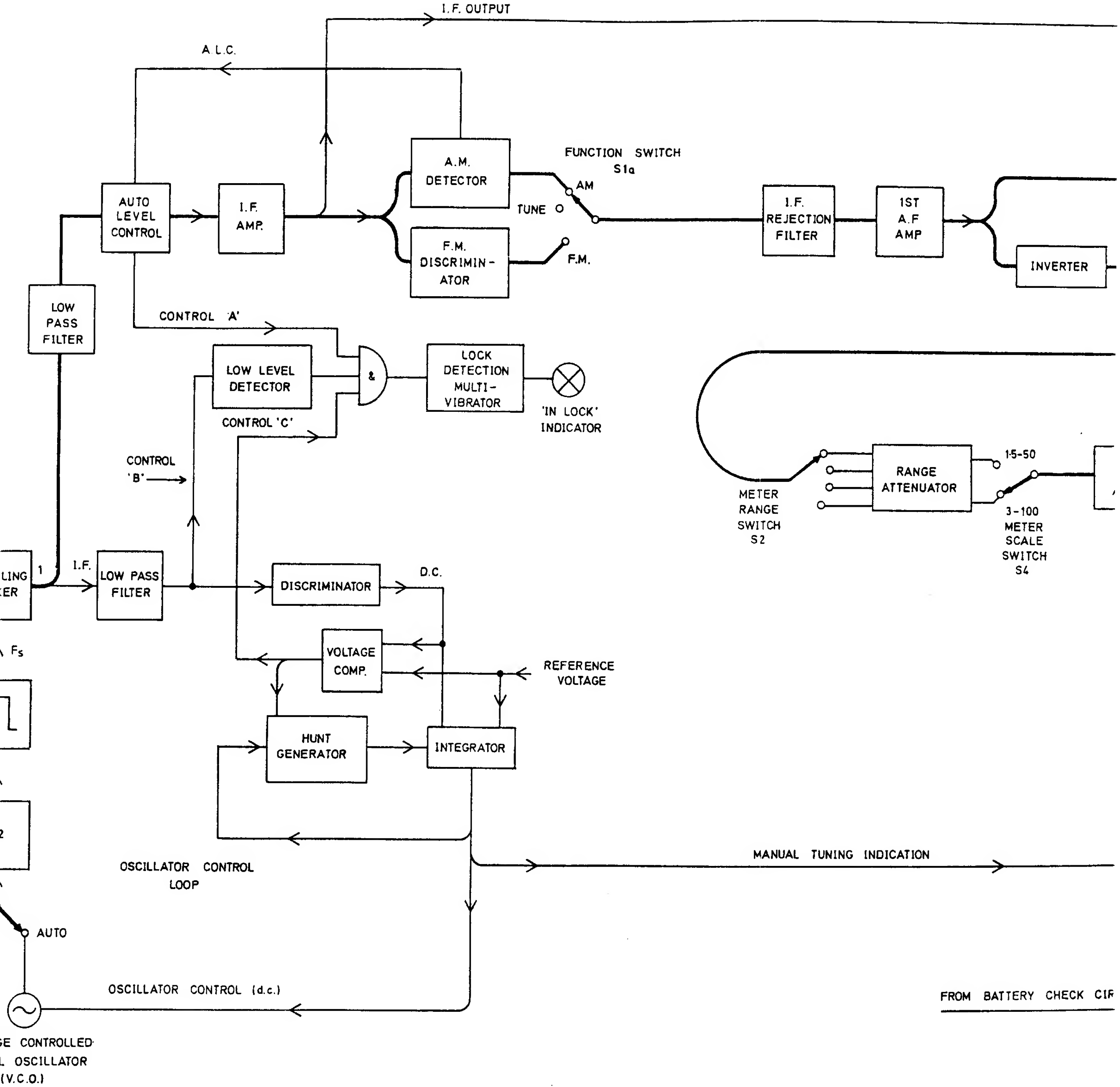
SAMPLING MIXER ASSEMBLY: 19-0742

Part No.	Description	Rat.	Tol. %	Value	Component References
	Resistors	watts		ohms	
20-2101	Carbon Film	$\frac{1}{4}$	5	100	R9, R10, R12
20-2102	Carbon Film	$\frac{1}{4}$	5	1k	R6
20-2153	Carbon Film	$\frac{1}{4}$	5	15k	R2, R3
20-2151	Carbon Film	$\frac{1}{4}$	5	150	R11
20-2220	Carbon Film	$\frac{1}{4}$	5	22	R4
20-2221	Carbon Film	$\frac{1}{4}$	5	220	R7, R8
20-2330	Carbon Film	$\frac{1}{4}$	5	33	R14
20-2470	Carbon Film	$\frac{1}{4}$	5	47	R5
20-2471	Carbon Film	$\frac{1}{4}$	5	470	R15, R16
20-2472	Carbon Film	$\frac{1}{4}$	5	4.7k	R13
20-2510	Carbon Film	$\frac{1}{4}$	5	51	R1
	Capacitors			F	
21-1531	Ceramic	200V	10	820p	C5
21-1676	Ceramic	63V	0.25p	4.7p	C2, C3
21-1616	Ceramic	12V	20	100n	C4, C6, C7
21-1709	Ceramic	100V	20	10n	C1
	Semiconductors				
22-1033	Diode, silicon				D1, D2, D3
22-1045	Diode, silicon				D4
22-1810	Voltage regulator	6.2V			D5
22-4122	Integrated Circuit, High-Speed Dual 'D' TTL (74H74N)				IC1
22-6017	Transistor, silicon, npn (2N2369)				Q4
22-6039	Transistor, silicon, npn (BFY90)				Q3
22-6059	Transistor, silicon, pnp (BFX89)				Q2
22-6101	Transistor, FET 'N' Channel (W300A)				Q1
	Inductors				
17-3194	Transmission Line Transformer				T1
17-3195	Inductor				L1

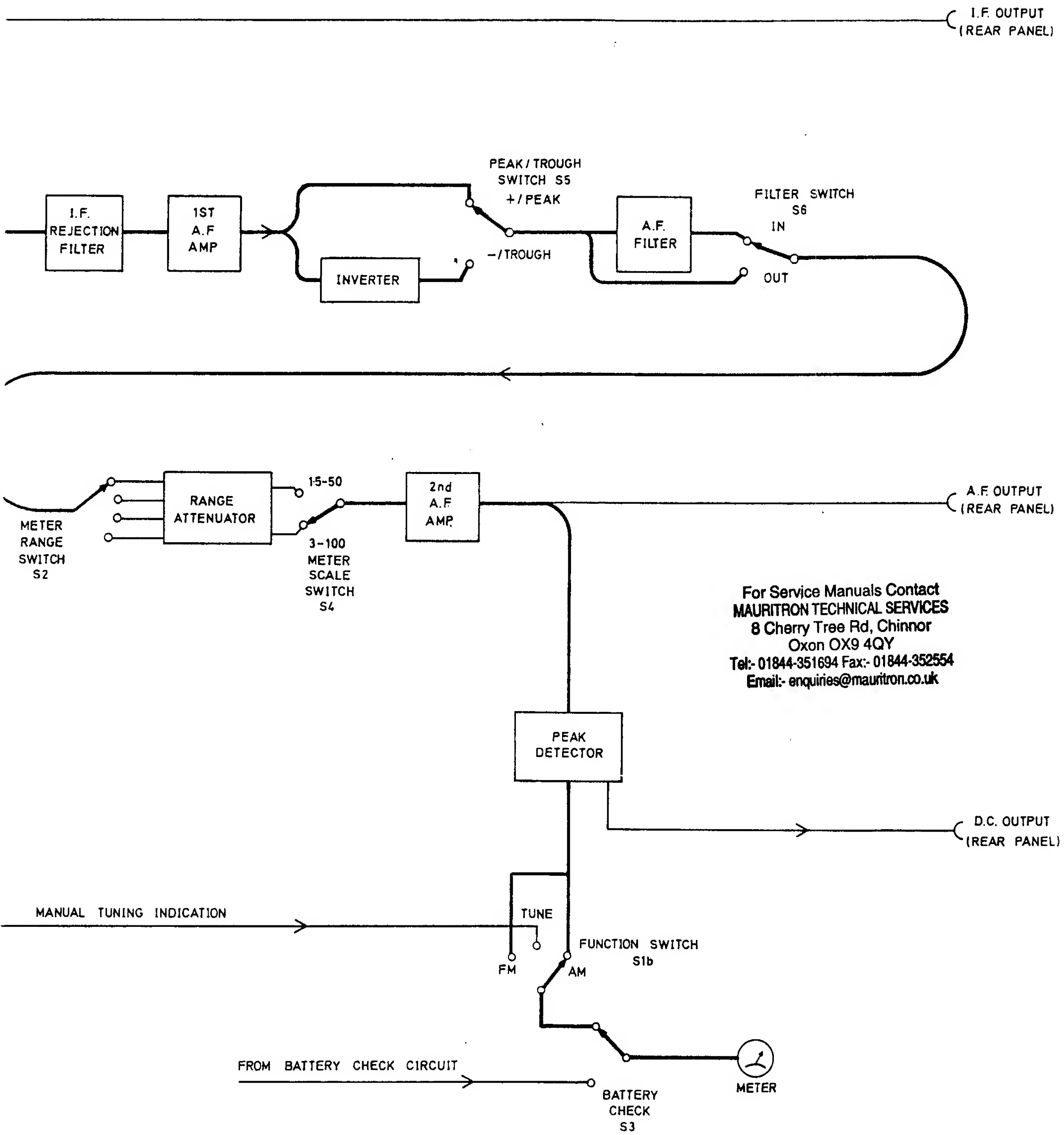


WOH 4105

Explanatory Block C

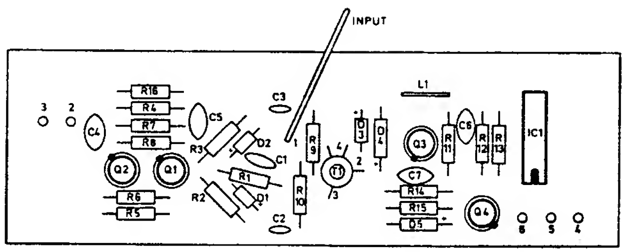


Explanatory Block Diagram: Modulation Meter 9009



: Modulation Meter 9009

Fig.2.1



19-0742/1

FIG. 2

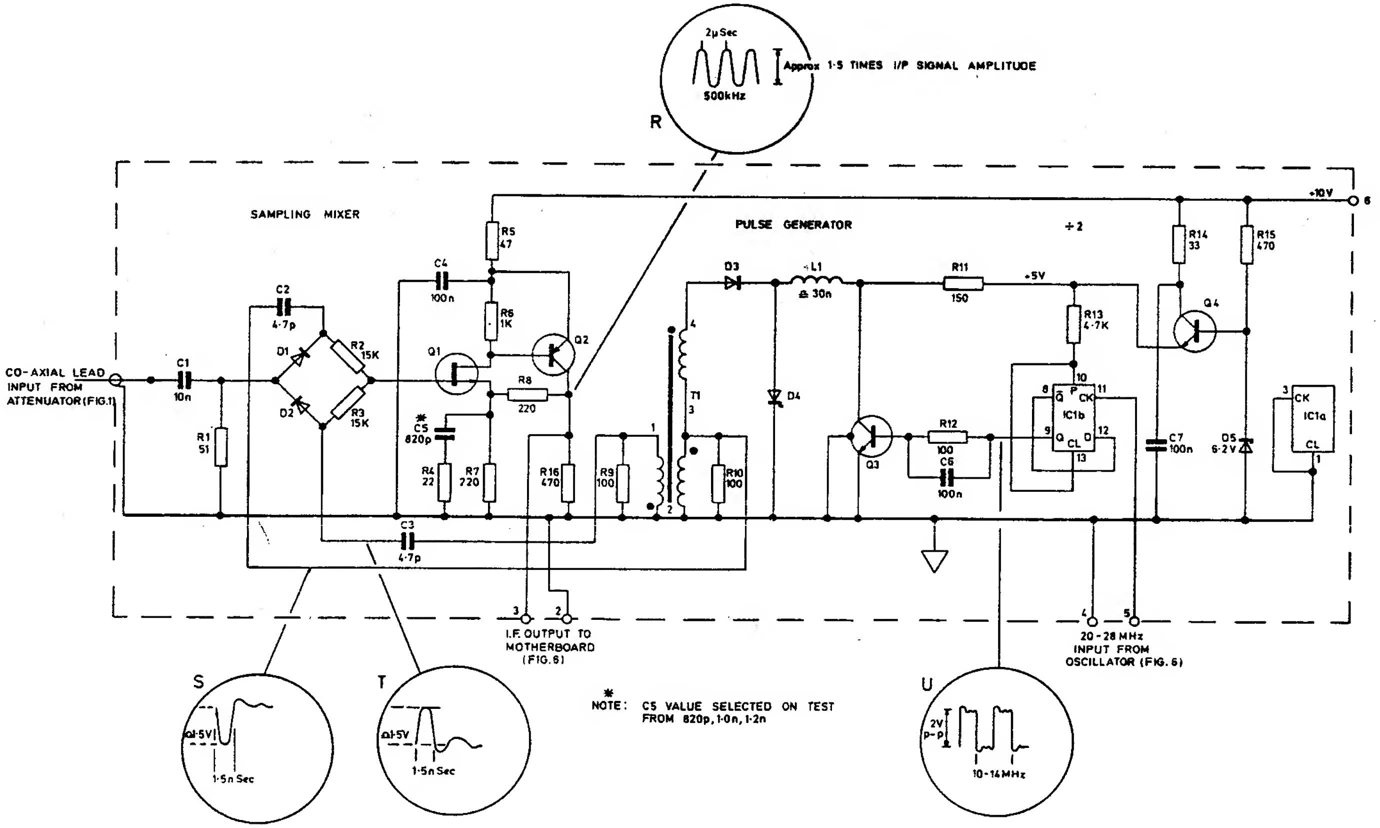
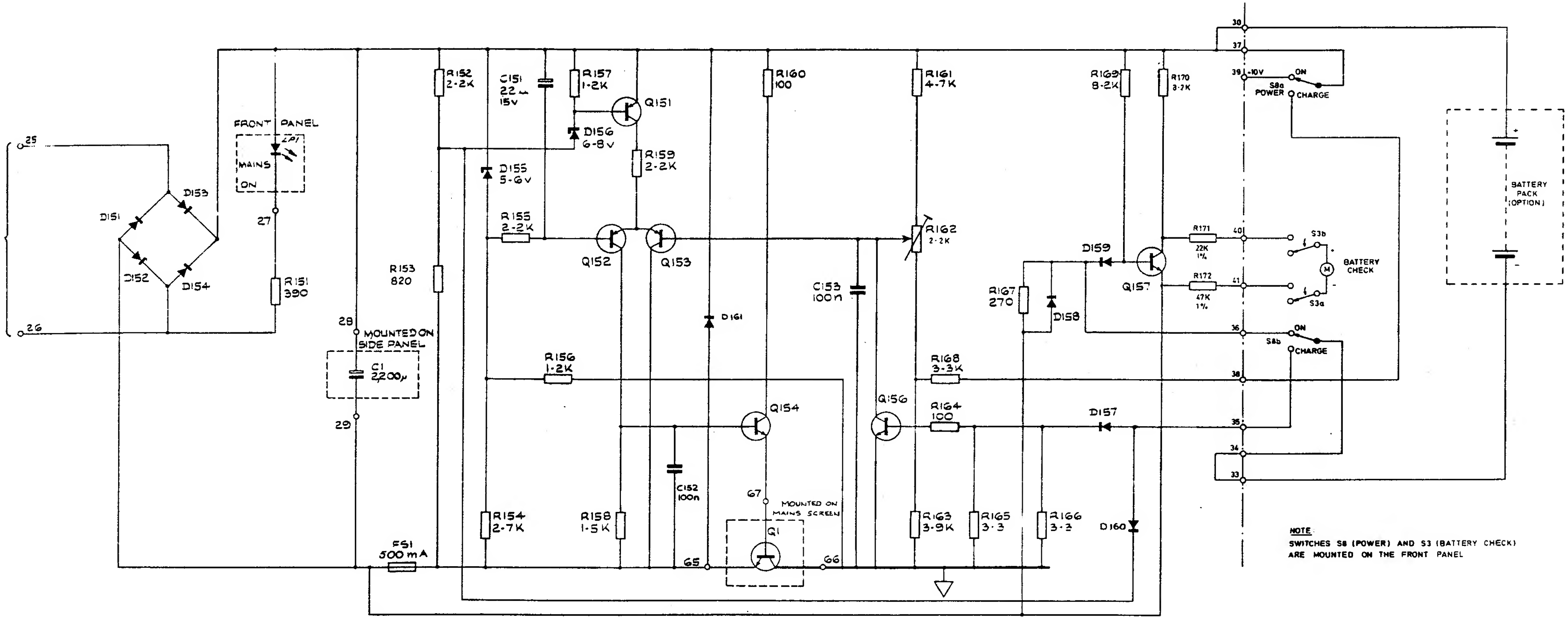


FIG. 3

19-0742/2

WOH 4105

Circuit and Layout: Sampling Mixer 19-0742 — Fig.2 Fig.3



NOTE

SWITCHES S8 (POWER) AND S3 (BATTERY CHECK) ARE MOUNTED ON THE FRONT PANEL

WOH 4105 19-0751/3

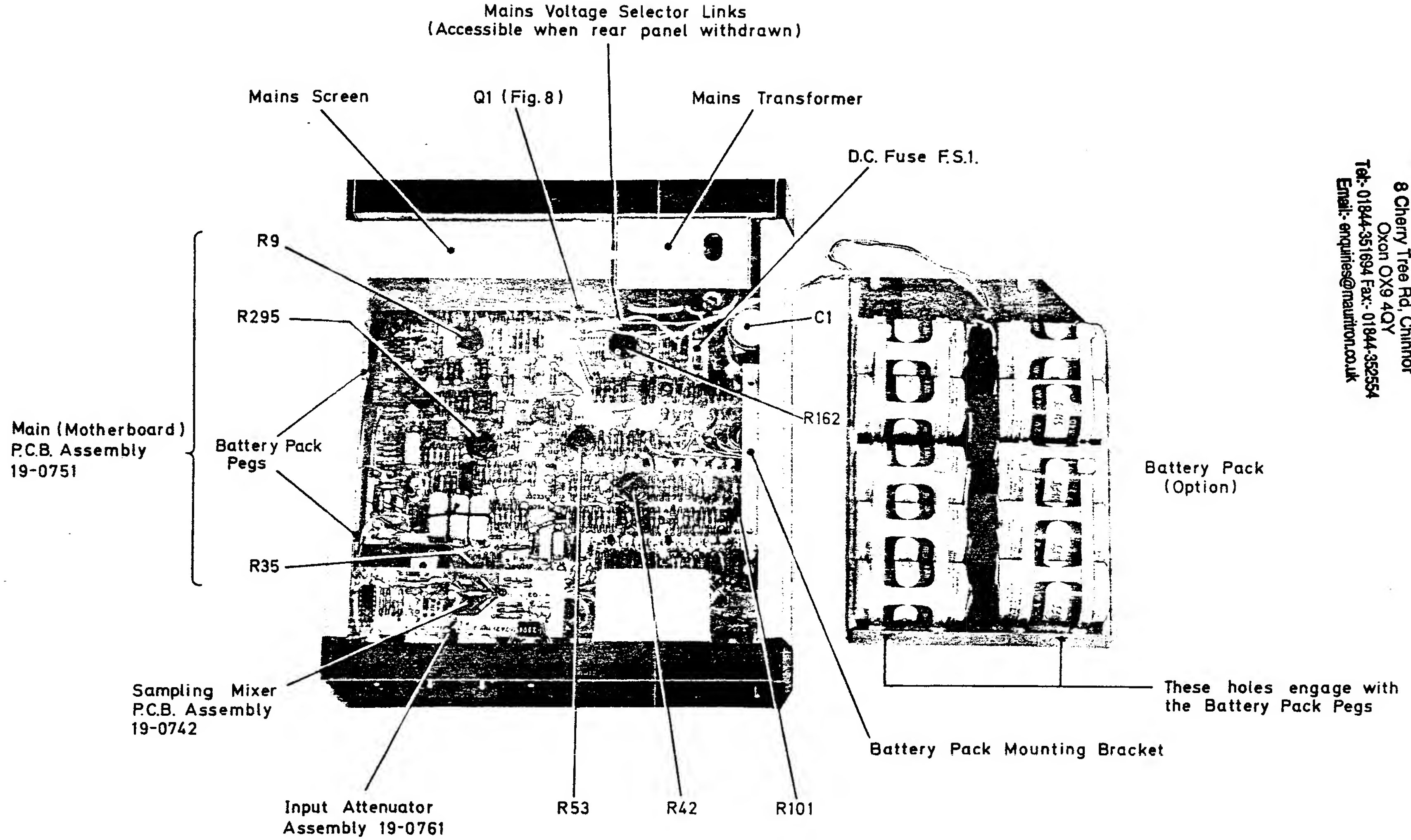
Circuit: Power Supply Section

(PART OF MOTHERBOARD P.C.B. 19-0751)

Power Supply

19-0751

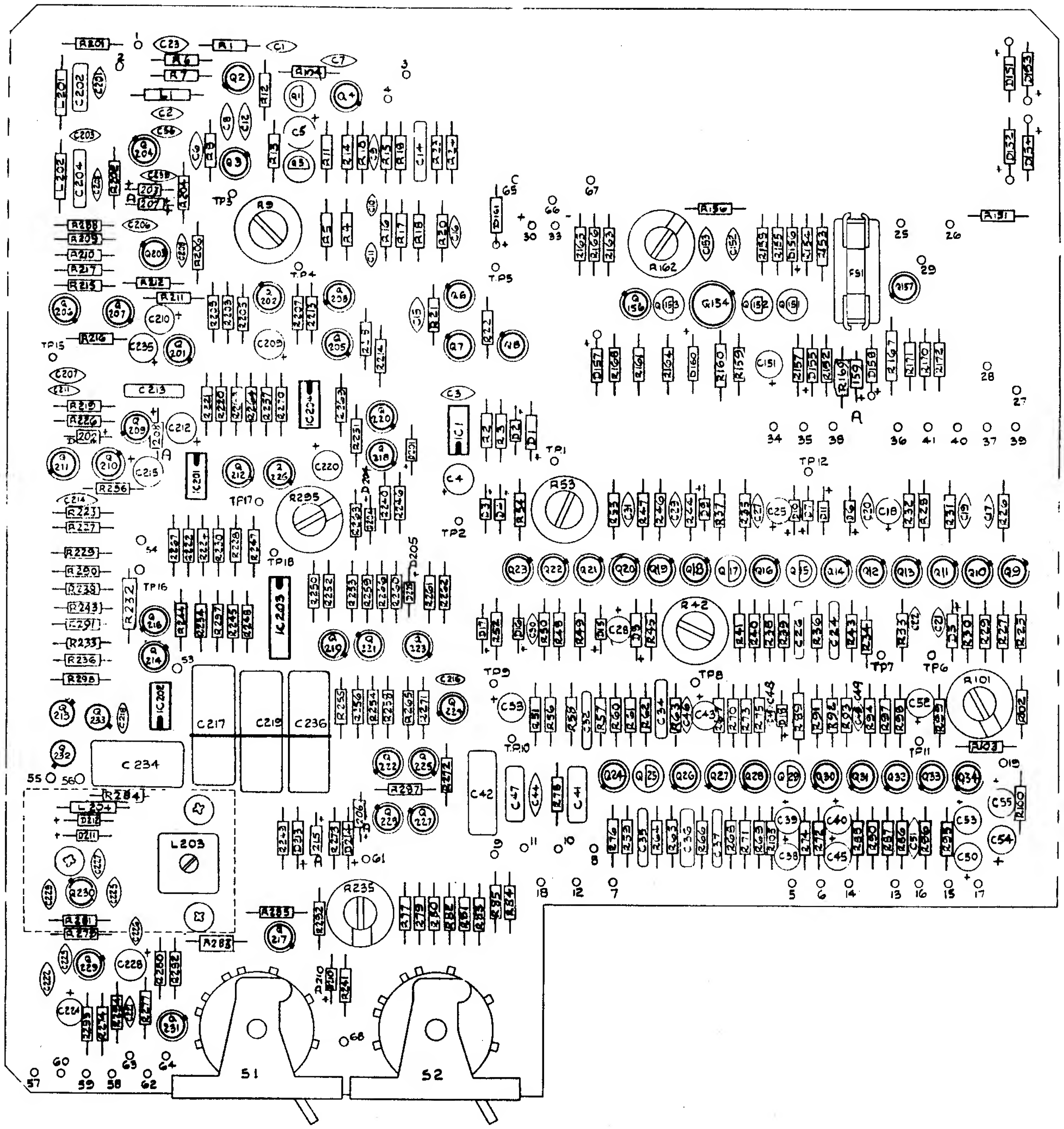
Fig. 4



Service View : 9009 (Underside)

Fig. 4.3

WOH4105	
A	

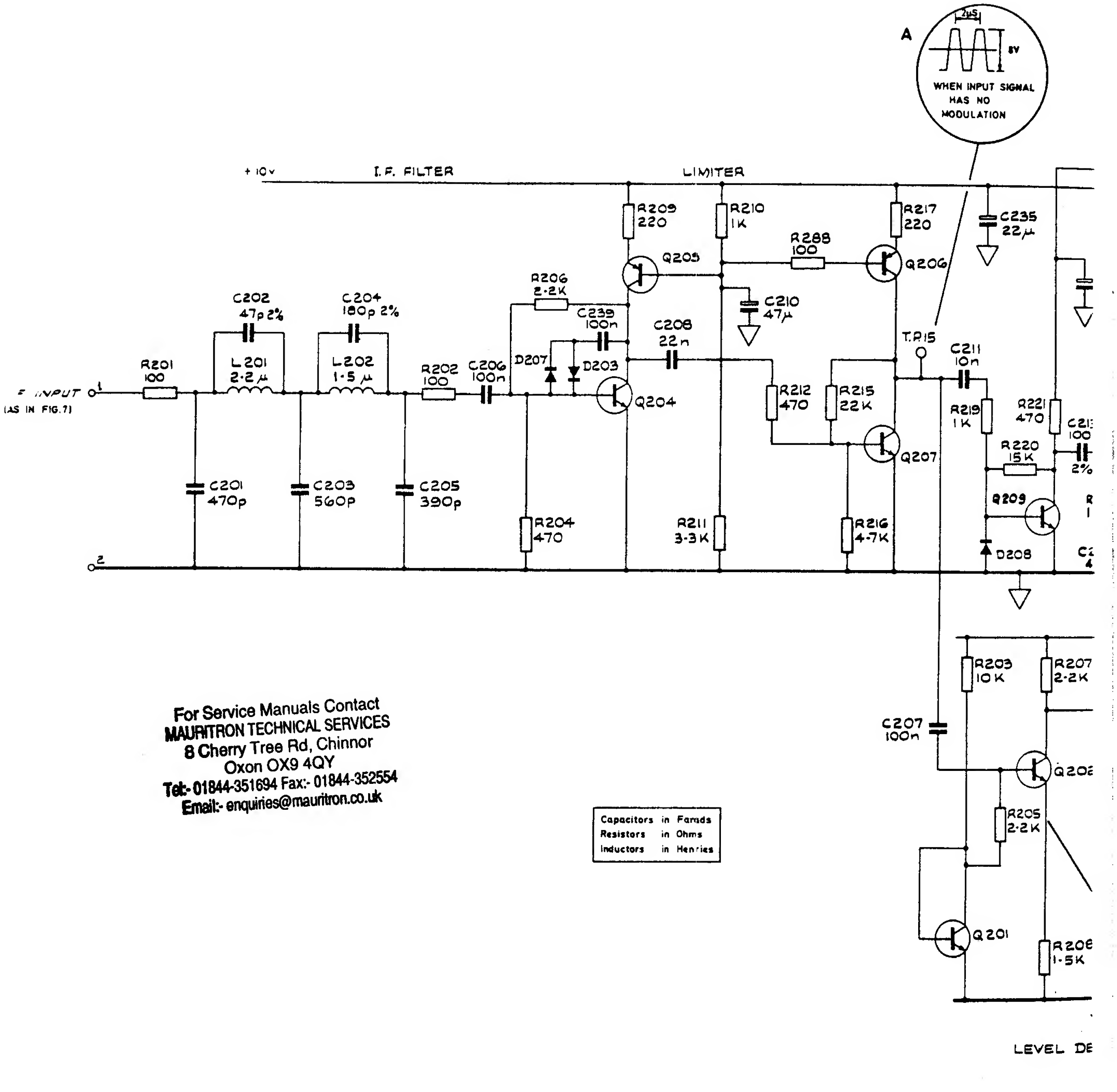


19-0751

Fig.5

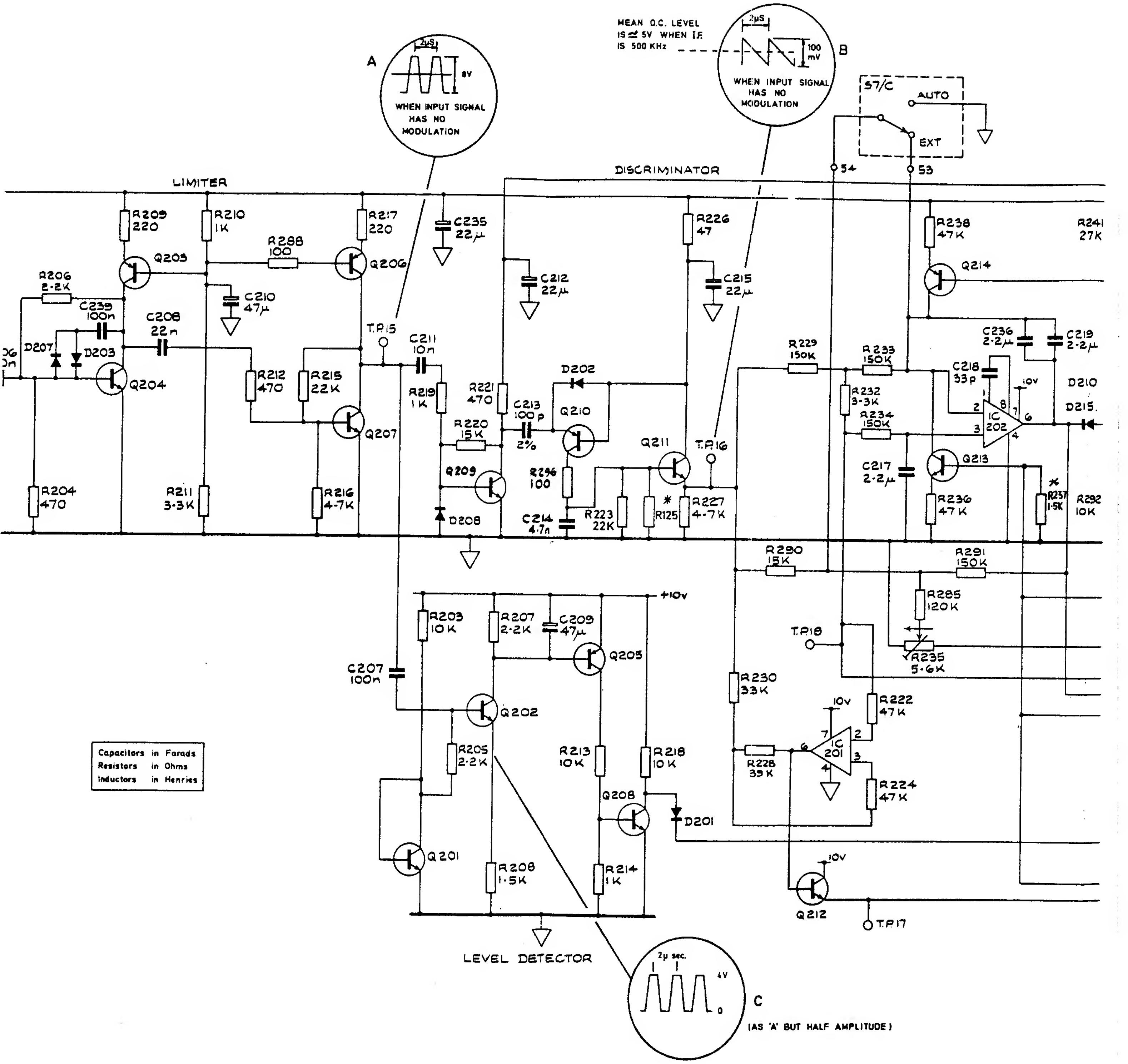
Layout : Motherboard P.C.B. 19-0751

WOH 4105 19-0751/1 1



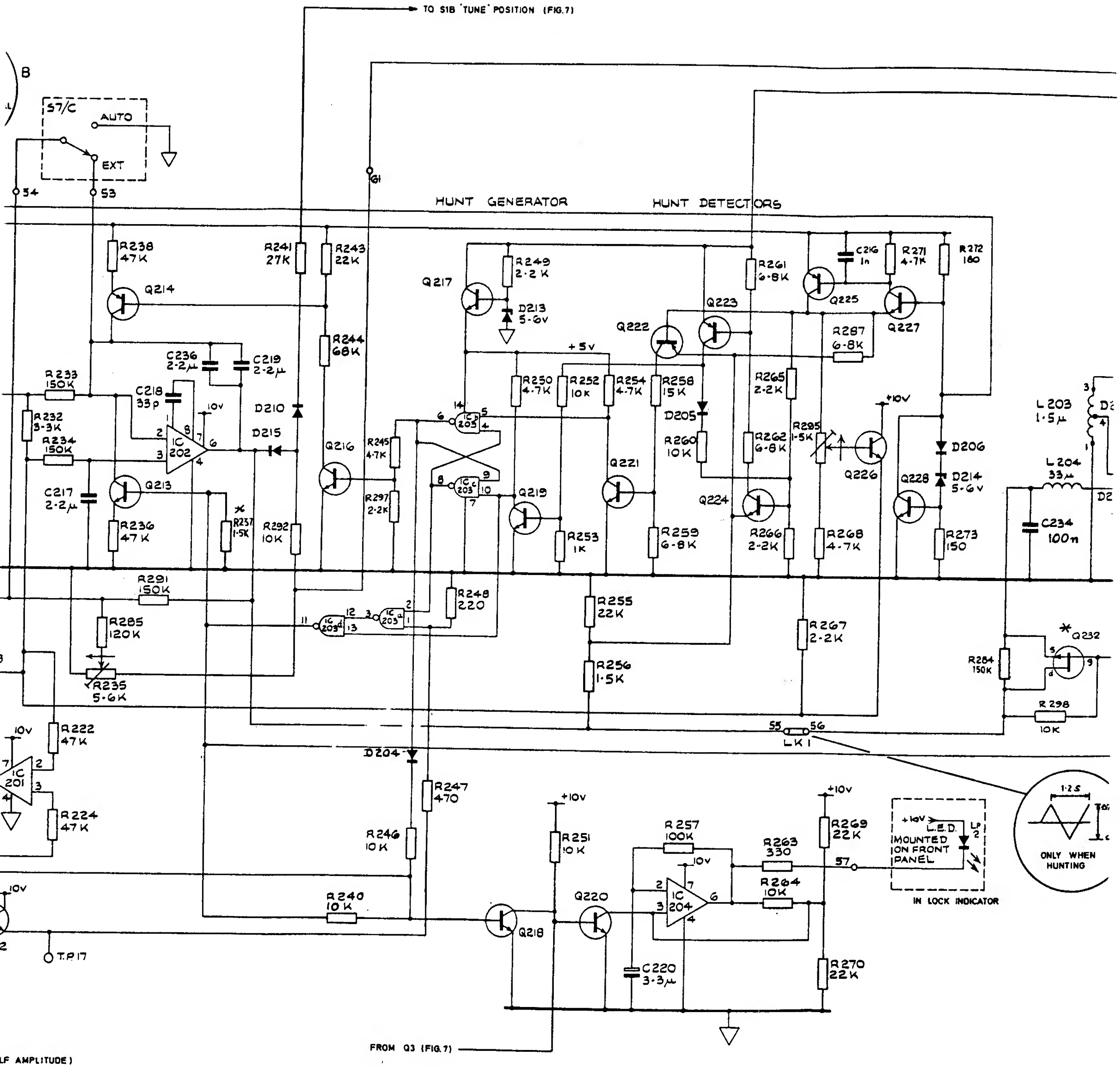
Capacitors	in	Farads
Resistors	in	Ohms
Inductors	in	Henries

WOH 4105	19-0751/4				
2	3	4	5	11	



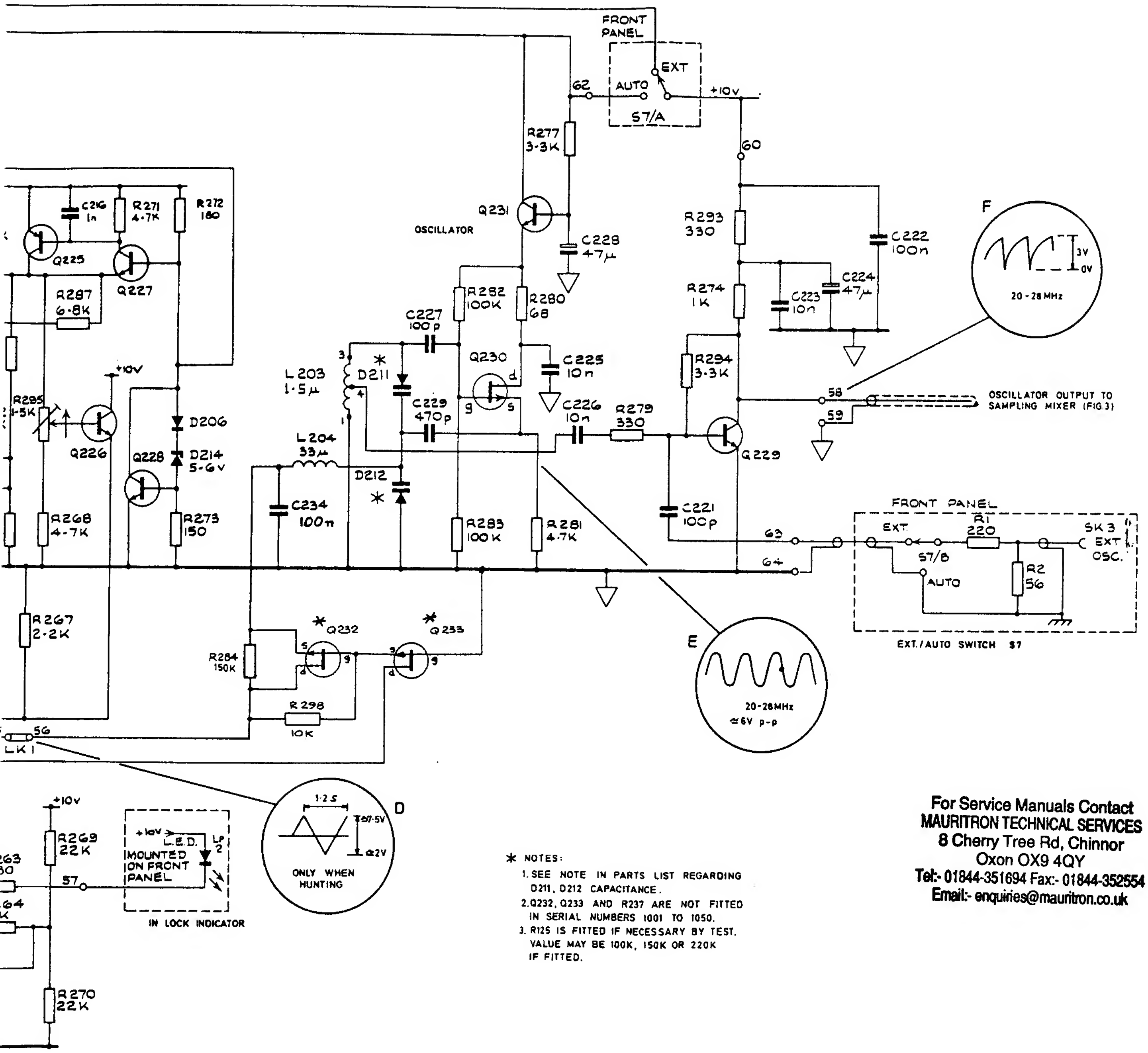
Circuit : Frequency Lock

(PART OF MOTHERBOARD P.C.B. 19-(



Circuit : Frequency Locked Loop

(PART OF MOTHERBOARD P.C.B. 19-0751)



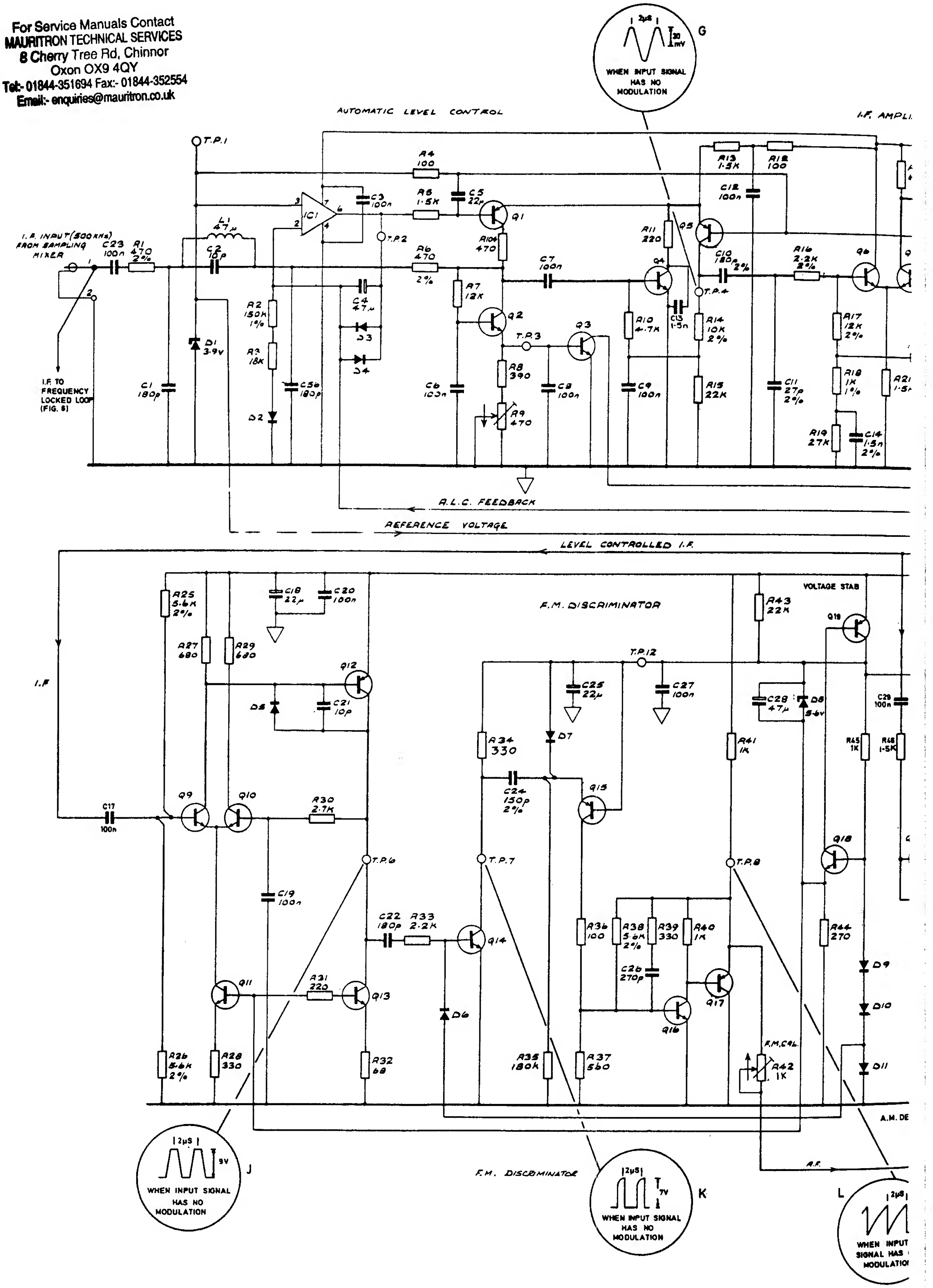
* NOTES:

1. SEE NOTE IN PARTS LIST REGARDING D211, D212 CAPACITANCE.
2. Q232, Q233 AND R237 ARE NOT FITTED IN SERIAL NUMBERS 1001 TO 1050.
3. R125 IS FITTED IF NECESSARY BY TEST. VALUE MAY BE 100K, 150K OR 220K IF FITTED.

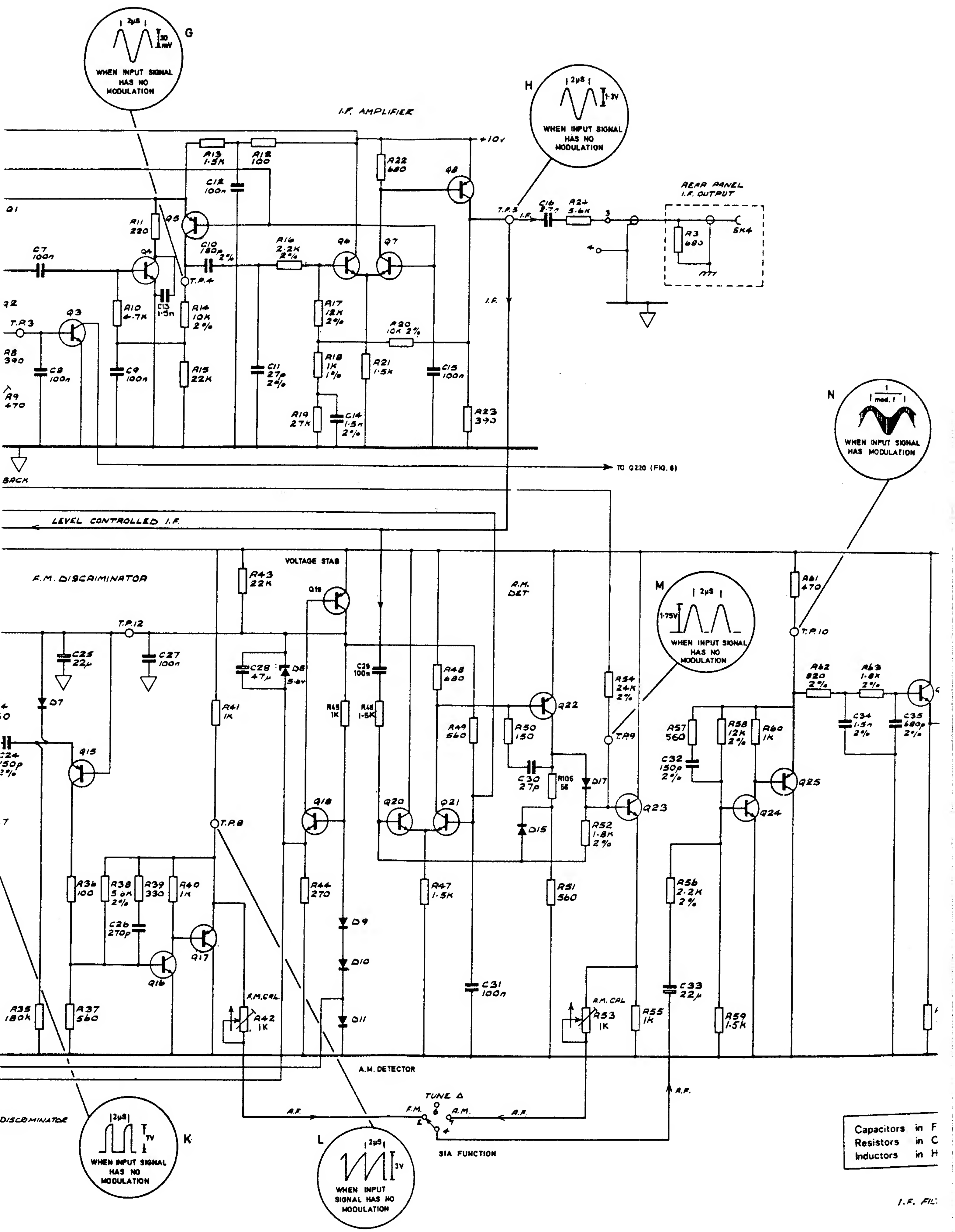
Motherboard

19-0751

Fig. 6

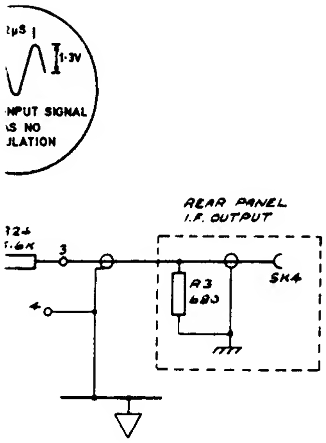


WOH4105 19-0751/2
1, 2, 3, 4, 5,



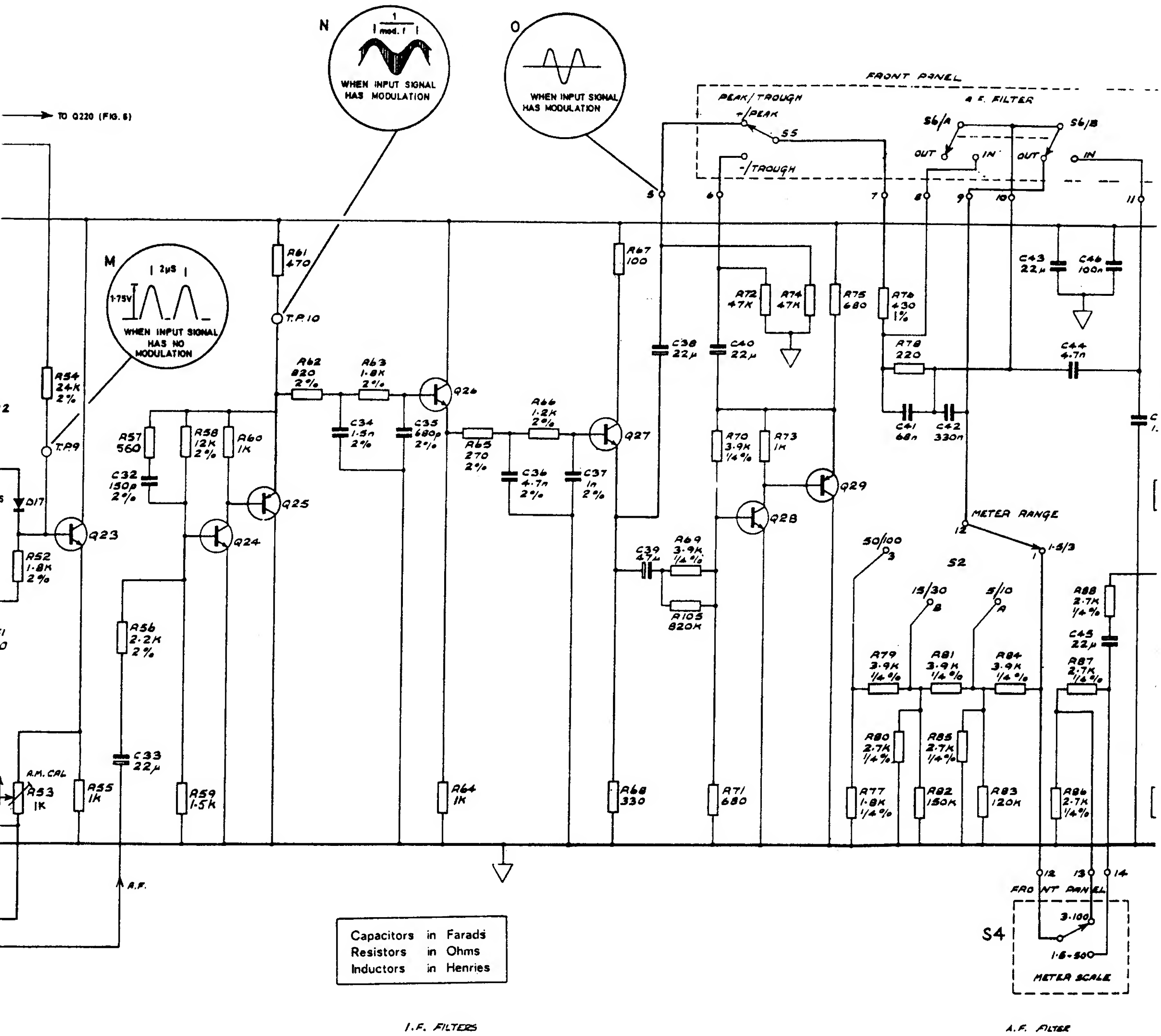
Measurement Circuits

(PART OF MOTHERBOARD P.C.B. 19-0751)



FAULT LOCATION TEST DATA

NOTE : CARRY OUT TESTS 'A' TO 'F' (SEE FIG. 6) AND OBTAIN LOOP LOCK BEFORE MAKING TESTS 'G' TO 'P'.

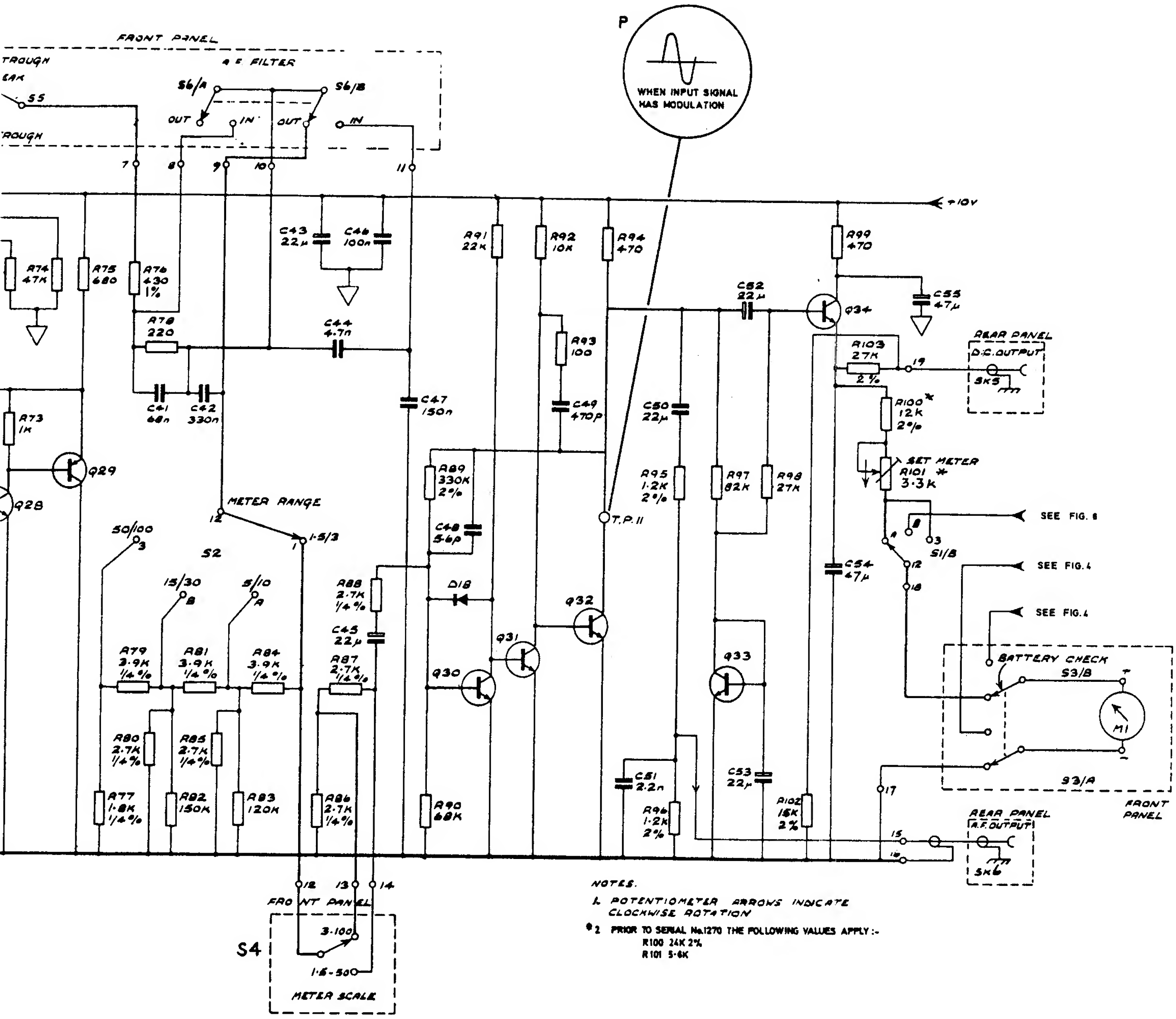


Capacitors in Farads
Resistors in Ohms
Inductors in Henries

urement Circuits
MOTHERBOARD P.C.B: 19-0751)

ɴ TEST DATA

OUT TESTS 'A' TO 'F' (SEE FIG. 6)
ɜTAIN LOOP LOCK BEFORE
TESTS 'G' TO 'P'



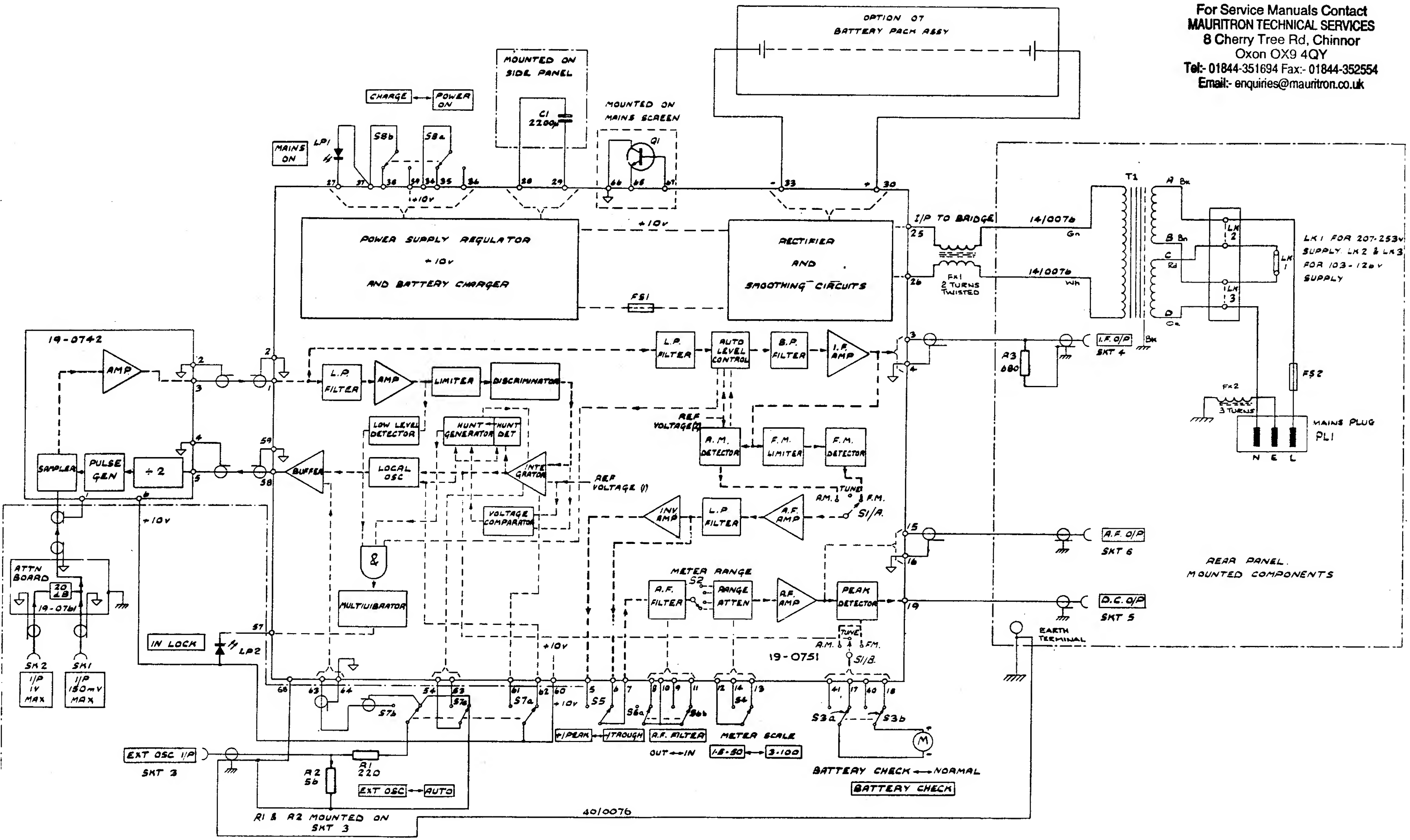
NOTES.
1. POTENTIOMETER ARROWS INDICATE CLOCKWISE ROTATION
*2 PRIOR TO SERIAL No.1270 THE FOLLOWING VALUES APPLY :-
R100 24K 2%
R101 5.6K

A.F. FILTER 2ND. A.F. AMPLIFIER PEAK DETECTOR

Motherboard

19-0751

Fig. 7



WOH 4105 | 9009/3 | 2

Overall Block Diagram : 9009

Fig. 8

COMPONENTS IN FIGURES 4, 5, 6 AND 7

MAIN (MOTHERBOARD) P.C.B. ASSEMBLY: 19-0751

Part No.	Description	Rat.	Tol. %	Value	Circuit Reference
	Resistors	W		Ω	
20-2006	Carbon Film	¼	5	3.3	R165,166
20-2101	Carbon Film	¼	5	100	R4,12,36, 67,93,164, 201,202, 288,296
20-2102	Carbon Film	¼	5	1k	R40,41,45, 55,60,64, 73,210, 214,219, 253,274
20-2103	Carbon Film	¼	5	10k	R92,203, 213,218,240, 246,251,252, 260,264,292, 298
20-2104	Carbon Film	¼	5	100k	R257,282, 283
20-2122	Carbon Film	¼	5	1.2k	R156,157
20-2123	Carbon Film	¼	5	12k	R7
20-2124	Carbon Film	¼	5	120k	R83,285
20-2151	Carbon Film	¼	5	150	R50,273
20-2152	Carbon Film	¼	5	1.5k	R5,13,21,47, 158,208,256
20-2152	Carbon Film	¼	5	1.5k	R59
20-2153	Carbon Film	¼	5	15k	R220,258,290
20-2154	Carbon Film	¼	5	150k	R82,229,233, 234,284,291
20-2181	Carbon Film	¼	5	180	R272
20-2183	Carbon Film	¼	5	18k	R3,
20-2184	Carbon Film	¼	5	180k	R35
20-2221	Carbon Film	¼	5	220	R11,31, 78,209,217, 248
20-2222	Carbon Film	¼	5	2.2k	R33,152,155, 159,205,206, 207,249,265, 266,267,297
20-2223	Carbon Film	¼	5	22k	R15,43,91, 215,223*,243, 255,269,270
	Selected by test. See NOTE on Fig. 6.				R125
20-2271	Carbon Film	¼	5	270	R44
20-2272	Carbon Film	¼	5	2.7k	R30,154
20-2273	Carbon Film	¼	5	27k	R19,98,103
20-2331	Carbon Film	¼	5	330	R28,34,39,68, 263,279,293
20-2332	Carbon Film	¼	5	3.3k	R168,211,232, 277,294
20-2333	Carbon Film	¼	5	33k	R230
20-2391	Carbon Film	¼	5	390	R8,23,151
20-2392	Carbon Film	¼	5	3.9k	R163
20-2393	Carbon Film	¼	5	39k	R228
20-2470	Carbon Film	¼	5	47	R226
20-2471	Carbon Film	¼	5	470	R61,94,99, 104,204,212, 221,247
20-2472	Carbon Film	¼	5	4.7k	R10,161,216, 227,245,250, 254,268,271, 281
20-2152	Carbon Film	¼	5	1.5k	R237

Part No.	Description	Rat.	Tol. %	Value	Circuit Reference
	Resistors	W		Ω	
20-2473	Carbon Film	¼	5	47k	R72,74,222, 224,236,238
20-2561	Carbon Film	¼	5	560	R37,49,51,57*
20-2562	Carbon Film	¼	5	5.6k	R24
20-2273	Carbon Film	¼	5	27k	R241
20-2680	Carbon Film	¼	5	68	R32,280
20-2681	Carbon Film	¼	5	680	R22,27,29, 48,71,75
20-2682	Carbon Film	¼	5	6.8k	R259,261, 262,287
20-2683	Carbon Film	¼	5	68k	R90,244
20-2822	Carbon Film	¼	5	8.2k	R169, 170
20-2823	Carbon Film	¼	5	82k	R97
20-2824	Carbon Film	¼	5	820k	R105
20-3101	Metal Oxide	½	5	100	R160
20-3271	Metal Oxide	½	5	270	R167
20-3821	Metal Oxide	½	5	820	R153
20-4007	Metal Oxide	¼	2	2.2k	R16,56
20-4008	Metal Oxide	¼	2	1.8k	R52,63
20-4010	Metal Oxide	¼	2	1.5k	R46
20-4012	Metal Oxide	¼	1	1k	R18
20-4018	Metal Oxide	¼	2	10k	R14,20
20-4019	Metal Oxide	¼	2	270	R65
20-4024	Metal Oxide	¼	2	1.2k	R66,95,96
20-4044	Metal Oxide	¼	1	430	R76
20-4109	Metal Oxide	¼	1	47k	R172
20-4052	Metal Oxide	¼	1	150k	R2
20-4067	Metal Oxide	¼	2	12k	R17,58
20-4069	Metal Oxide	¼	2	820	R62
20-4077	Metal Oxide	¼	2	5.6k	R25,26,38
20-4084	Metal Oxide	¼	2	470	R1,6
20-4101	Metal Oxide	¼	2	24k	R54,100
20-4449	Metal Oxide	½	2	330k	R89
20-4866	Metal Film		½%50ppm	1.8k	R77
20-4868	Metal Film		½%50ppm	2.7k	R80,85,86, 87,88
20-4869	Metal Film		½%50ppm	3.9k	R69,70,79, 81,84
20-4029	Metal Oxide	¼	1	22k	R171
20-6541	Potentiometer	¼	20	470	R9
20-6542	Potentiometer	¼	20	1k	R42,53
20-6557	Potentiometer	¼	20	1.5k	R295
20-6594	Potentiometer	¼	20	5.6k	R235
20-6544	Potentiometer	¼	20	3.3k	R101
20-4021	Metal Oxide	¼	2	15k	R102
20-4025	Metal Oxide	¼	2	27k	R103
20-6543	Variable			2.2k	R162
	Capacitors				
21-1000	Tantalum	35V	20	3.3µ	C220
21-1038	Tantalum	6.3V	20	47µ	C4,28,39, 209,224
21-1039	Tantalum	16V	20	22µ	C5,25, 33,38,40, 43,45,50, 52,53,151, 212,215,235
21-1045	Tantalum	16V	20	47µ	C18,54,55, 210,228
21-1508	Ceramic	200V	10	10p	C2, 21
21-1513	Ceramic	200V	10	27p	C30

Part No.	Description	Rat.	Tol. %	Value	Circuit Reference
	Capacitors				
21-1514	Ceramic	200V	10	33p	C218
21-1520	Ceramic	200V	10	100p	C221,227
21-1523	Ceramic	200V	10	180p	C1,22,56
21-1527	Ceramic	200V	10	390p	C205
21-1528	Ceramic	200V	10	470p	C49,201,229
21-1529	Ceramic	200V	10	560p	C203
21-1532	Ceramic	200V	20	1n	C216
21-1537	Ceramic	200V	20	2.7n	C16
21-1545	Ceramic	100V	20	10n	C211,223,225,226
21-1546	Ceramic	100V	20	22n	C208
21-1616	Ceramic	12V	20	100n	C3,6,7,8,9,12,15,17,19,20,23,27,29,31,46,152,153,206,207,222,239
21-1534	Ceramic	100V	20	1.5n	C13
21-1633	Ceramic	200V		4.7n	C44,214
21-1643	Ceramic	200V		2.2n	C51
21-1677	Ceramic	±0.25p		5.6p	C48
21-1685	Ceramic		2	27p	C11
21-1695	Ceramic		2	180p	C10
21-3017	Silver Mica	200V	2	47p	C202
21-3031	Silver Mica	200V	2	100p	C213
21-3035	Silver Mica	200V	2	150p	C24,32
21-3037	Silver Mica	200V	2	180p	C204
21-3041	Silver Mica	200V	2	270p	C26
21-3051	Silver Mica	200V	2	680p	C35
21-3061	Silver Mica	200V	2	1n	C37
21-3065	Silver Mica	350V	2	1.5n	C14,34
21-3077	Silver Mica	350V	2	4.7n	C36
21-4505	Polyester	100V	20	68n	C41
21-4506	Polyester	100V	20	100n	C234
21-4555	Polyester		5	330n	C42
21-4556	Polyester	100V	5	150n	C47
21-4557	Polyester	100V	20	2.2u	C217,219,236
	Diodes				
22-1033	Germanium				D5
22-1029	Silicon				D2,3,4,6,7,9,10,11,15,16,17,18,159,160,201,202,203,204,205,206,207,208,210,215
22-1061	Varactor, 'hyper abrupt,' See NOTE.				D211,212

NOTE: Circuit diagram Fig. 6 shows the varactor diodes D211/D212 when types 22-1061 are fitted.
If Motorola diodes (22-1051) are fitted a 33pF ceramic capacitor (21-1514) is wired across each diode. These capacitors must not be fitted with diodes 22-1061.

Part No.	Description	Rat.	Tol. %	Value	Circuit Reference
22-1602	Silicon				D151,152,153,154,157,158,161

Part No.	Description	Rat.	Tol. %	Value	Circuit Reference
	Diodes				
22-1809	Voltage regulator	5.6V	5		D213
22-1811	Voltage regulator	6.8V	5		D156
22-1905	Voltage regulator	3.9V	5		D1
22-1909	Voltage regulator	5.6V	5		D155
22-1927	Voltage regulator	5.6V	2		D8,214
	Integrated Circuits				
22-4044	Quad 2i/p Pos Nand Gate (7400)				IC203
22-4111	High Performance Op.Amp. (741C)				IC1,201,204
22-4203	Op.Amp. (LM301AN Selected)				IC202
	Transistors				
22-6130	Silicon: npn (BC109 Metal can)				Q16,27,28
22-6010	Silicon: pnp (2N4126)				Q1,5,15,17,25,29
22-6017	Silicon: npn (2N2369)				Q11,13,18,156,201,202,204,208,209,212,216,217,218,219,220,221,224,226,228,229
22-6041	Silicon: npn (BC109)				Q2,3,4,6,7,9,10,14,20,21,23,24,26,30,31,32,33,34,157,207,211,213,227,231
22-6044	Silicon: npn (BFY51)				Q154
22-6058	Silicon: pnp (BFX48)				Q8,12,19,22,203,205,206,210,214,222,223,225
22-6101	Silicon: FET (W300A)				Q230,233
22-6113	Silicon: pnp (ZTX550)				Q151,152,153
22-6120	Silicon: FET (E201)				Q232
	Inductors				
23-7078	Inductor (Delevan)			47uH	L1
23-7066	Inductor (Delevan)			2.2uH	L201
23-7065	Inductor (Delevan)			1.5uH	L202
17-3193	Inductor (Racal)			-	L203
23-7077	Inductor (Delevan)			33uH	L204
	Miscellaneous				
17-0086	Switches, rotary				S1,S2
23-0004	Fuselink, quick action			500mA	FS1
23-0034	Fuseholder				

SECTION 4

APPENDICES

AND

CHANGE INFORMATION

COMPONENTS IN FIGURE 8

NOTE: The following components are not mounted on any p.c.b. but are located on the main chassis, the front panel assembly or the rear panel.

CHASSIS ASSEMBLY COMPONENTS (11-1005)

Ref.	Description	Part No.
R1	Resistor Carbon Film $\frac{1}{4}$W 5% 220 Ω	20-2221
R2	Resistor Carbon Film $\frac{1}{4}$W 5% 56 Ω	20-2560
C1	Capacitor Electrolytic 40V 2200µ	21-0581
Q1	Transistor Silicon, npn, medium power (MJE520)	22-6081
FX1) FX2)	Ferrite core (toroid)	23-8032

FRONT PANEL MOUNTING ASSEMBLY (11-0927)

Ref.	Description	Part No.
M1	Meter 0-200µA Sifam DS38 to Racal drawing 23-2013	
D1) D2)	LED lamps	26-5003
Sockets		
SK1,SK2	BNC, Bulkhead	23-3198
SK3	BNC, Bulkhead	23-3005
Switches		
S3	Toggle, DPDT (biased)	23-4073
S4,S5	Toggle, SPDT	23-4065
S6,S8	Toggle, DPDT	23-4043
S7	Toggle, 3PDT	23-4072

NOTE: For switches S1 and S2 refer to Parts List 19-0751.

REAR PANEL ASSEMBLY (11-0928)

R1,R2 (resistors mounted on SK3). Refer to Chassis Assembly, Parts List above.

R3, Resistor. Carbon Film $\frac{1}{4}$W 5% 680	20-2681
T1 Transformer Assembly, mains	11-0938
FS2 Fuselink (200-240V surge resisting: 80mA	23-0029
(110-120V surge resisting: 160mA	23-0019
Fuseholders, panel mounting 5 x 20 mm IEC	23-0044
PL1 Mains receptacle (IEC)	23-3194
SK4,SK5,SK6 Sockets BNC, bulkhead	23-3005

OPTIONAL BATTERY PACK ASSEMBLY (11-0926) £65.

Batteries. Re-chargeable. Quantity 10 — 23-2502

(Ni-Cad cells 1.2V 4 AH with solder tags.)

e.g. Ever-Ready NCC400
Alkaline Batteries W4
Saft VR4

AM/FM MODULATION METER 9009

AMENDMENTS

Fig. 6 Circuit: Frequency Locked Loop

Under NOTES, item 3, referring to the alternative values for R125, change 220K to read 330K.

Fig. 7 Circuit: Measurement Circuits 19-0751

The value of C18 is changed to 47μF. The details in Parts List 3a are correct.